

**Montrose Technical Responses to  
EPA Comments dated January 27, 2010 on the  
DNAPL Feasibility Study dated April 21, 2009**

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**Format of Montrose Responses**

EPA comments are shown first in italics followed by the Montrose response in standard text. Due to the length of the comments, only excerpts from the EPA comments are provided where necessary to address key technical issues. The entire EPA comment is not repeated in many cases.

Not all EPA comments are addressed in these responses, but we believe that all major technical issues have been addressed. Due to the repetitiveness of the comments, responses are grouped together by technical issue rather than respond to each comment in numerical order. The technical categories grouped together and presented in these responses are summarized below. Additionally, comments pertaining to ARARs or compliance with RAOs are addressed separately by Latham & Watkins.

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## Comments Related to Nature and Extent of DNAPL Contamination

### EPA Comment

*Dissolved MCB Plume Expansion in the Bellflower Sand (BFS): In General Comment No. 4, EPA indicated that..."The 2006 Groundwater Monitoring Results report indicates that the plume may be expanding both down gradient and up gradient in the Bellflower Sands."*

*Downgradient: "According to Table 3 of this report, well BF-28, at the southeastern toe of the plume, increased in chlorobenzene concentration from <1.0 on March 2, 2006, to 58 µg/l in October 2006. The previous high chlorobenzene concentration in this well was 5 µg/l. The p-CBSA concentration in this well in October 2006 was 1,200 µg/l. Thus, significant amounts of chlorobenzene, approaching the groundwater cleanup concentration of 70 µg/l, have reached this well in the last couple years. This indicates that the dissolved phase plume is expanding in the downgradient direction in the Bellflower Sands."*

*Upgradient: "Monitoring well BF-35, which is located approximately 200 feet north of the Montrose property, showed an increase in chlorobenzene concentration from 630 µg/l on October 26, 2004, to 1,500 µg/l in October 2006, and a p-CBSA concentration of 6,800 µg/l in October 2006. Another well in this area, CMW001, also had a chlorobenzene concentration of 6,000 µg/l in October 2006. The increases in chlorobenzene concentration in the up gradient groundwater direction is unexpected, and it appears that DNAPL is moving to the north from the site under the former Boeing property. Given these high concentrations, it is likely the DNAPL extends up gradient (further to the north) of these wells. Small concentrations of DDT were also found in the Bellflower sands to the north of the CPA (FS, page 2-15)."..."Based upon these findings, EPA is concerned that DNAPL may already be migrating outside of the containment zone."*

### Montrose Response

*Downgradient:* Montrose does not agree with EPA's evaluation of the downgradient groundwater monitoring data in the Bellflower Sand (BFS). EPA has not considered the April 2009 result from well BF-28, where MCB was detected at a concentration of 11 ug/L. The April 2009 result is approximately five times lower than the October 2006 result and approximately seven times lower than the groundwater cleanup goal established in the Record of Decision (ROD). The concentration of MCB in BF-28 has decreased over the last 3 years and the concentration trend in this well does not suggest that the MCB plume is expanding downgradient. The April 2009 results were reported to EPA in a document entitled *Supplemental Groundwater Sampling and Analysis Results, April 2009, Montrose Superfund Site, Los Angeles, California* (H+A, 2009).

EPA has also not considered the MCB concentration trend in other BFS wells located at the toe of the dissolved-phase plume. In addition to BF-28, wells BF-25 and BF-26 are located at the toe of the dissolved MCB plume in the BFS (see **Figure 1**). The concentration trend at these wells are plotted versus time in **Figure 2** and summarized as follows:

Well BF-25: The MCB concentration has decreased from 75 ug/L in July 1991 to 50 ug/L in October 2006, although it is recognized that the MCB concentration increased in this well from 2004 to 2006.

Well BF-26: The MCB concentration has decreased from 46 ug/L in October 1991 to <2 ug/L in October 2006.

There is no technical evidence to suggest that the toe of the MCB plume in the BFS is expanding downgradient. Furthermore, the pCBSA concentrations at these three wells have either been stable or declining over time, and the most recent pCBSA results from wells BF-25 and BF-26 (430 and <10 mg/L respectively in October 2006) were the lowest concentrations detected to date at these two wells.

Upgradient: Montrose does not agree that an increasing dissolved MCB concentration trend is due to DNAPL migration within the BFS or that the DNAPL migration is approaching the TI Waiver Zone boundary. There are three BFS monitoring wells located within the dissolved MCB plume north of the Montrose Property including BF-35, CMW001, and CMW002. The MCB concentration trends in these three wells are plotted in **Figure 3** and summarized as follows:

- Well BF-35: The MCB concentration has increased from 320 ug/L in September 2004 to 1,500 ug/L in October 2006, as indicated by EPA.
- Well CMW001: The MCB concentration increased from 7,300 ug/L in October 2003 to a peak of 15,000 ug/L in March 2005 but has since declined to 5,800 ug/L in March 2009.
- Well CMW002: The MCB concentration increased from 3,600 ug/L in October 2003 to 9,700 ug/L in March 2005 and has remained relatively stable since that time. In March 2009, the MCB concentration in this well was 11,000 ug/L.

CMW001 is located near the TI Waiver Zone boundary but has been exhibiting a declining MCB concentration trend since March 2005. BF-35 and CMW002 are located south of the TI Waiver Zone boundary, and CMW002 has been exhibiting a relatively stabilized MCB concentration trend since 2005. An increasing MCB concentration trend is occurring at BF-35, but Montrose disagrees that DNAPL migration to the north within the BFS is the cause for the following reasons:

- DNAPL has not been definitively observed within the BFS. EPA has previously interpreted the presence of DNAPL within the BFS based on discrete MCB groundwater sample results collected at BF-9 and BFSB-1 in 2008. However, the pCBSA concentrations from these wells exhibited the same concentration profile as MCB, suggesting that the profile is not a result of DNAPL within the BFS since pCBSA is not a component of DNAPL. These sampling locations are more than 500 feet south of BF-35.
- The MCB concentration at BF-35 is only 0.3% of the solubility limit.
- The MCB concentration at CMW001 is only 1.2% of the solubility limit and is declining, suggesting that DNAPL is not present in the BFS at this location.
- The MCB concentration at CMW002 is 2.2% of the solubility limit but is less than half of the dissolved MCB concentrations observed in downgradient monitoring wells located up to 3,000 feet from the Montrose Property where no DNAPL is present (e.g., 26,000 ug/L at BF-24). Therefore, MCB concentrations exceeding 1% of the solubility limit are not necessarily indicative of DNAPL presence and should not be the sole basis for determining DNAPL migration.
- Even if DNAPL is present in the BFS at the Montrose Property, there is no evidence that the DNAPL occurs in saturations high enough to be mobile under gravitational forces. The MCB component of the DNAPL will tend to solubilize in groundwater as it flows through the BFS beneath the Site, reducing the DNAPL saturation over time. There is no evidence to suggest that DNAPL is present in saturations high enough to be mobile within the BFS.

- DNAPL occurs within the Upper Bellflower Aquitard (UBA), overlying the BFS. The northern limit of DNAPL occurrence within the UBA was documented during investigation activities in 2004. No DNAPL was detected in reconnaissance boring TSB-16 drilled at the southern side of the former Boeing Property, more than 500 feet south of the TI Waiver Zone boundary (see Figure 2.27 of DNAPL FS).
- DNAPL migrates down-dip (i.e., downslope) along the top of capillary barriers, and the lithologic beds beneath the Montrose Property have been shown to dip easterly as shown in Figure 1.15 of the DNAPL FS (not northerly). Even in the UBA where up to 796,000 pounds of DNAPL may be present, the DNAPL migrated a maximum distance of 250 feet to the east.
- BF-35 and CMW002 are located hydraulically up- and cross-gradient from the Montrose Site and approximately 200 feet south of the TI Waiver Zone. The TI Waiver Zone boundary is located approximately 560 feet north of the Montrose Property.

For DNAPL to be migrating north under the former Boeing Property and near the TI Waiver Zone, it would (a) have to be present in the BFS, (b) occur in saturations high enough to be mobile under gravity, (c) migrate cross-dip and hydraulically up/cross-gradient, (d) occur in high enough quantities to not reach residual saturation over the 560 foot lateral distance between the Montrose Property and TI Waiver Zone, and (e) overcome the solubilizing effects of the groundwater flow within the BFS. It is exceptionally unlikely that DNAPL occurs within the BFS in accordance with the aforementioned requirements. Therefore, it is exceptionally unlikely that DNAPL is migrating north under the former Boeing Property and threatening the TI Waiver Zone boundary.

#### **EPA Comment**

*MCB Mass in the BFS: In referring to implementation of a hot floor as part of a focused steam injection remedial alternative (RA 5A), EPA indicated in Specific Comment No. 81 that..."Based upon observed dissolved phase concentrations there may be 10,000 lbs of MCB already in the Bellflower Sand which would also be volatilized and recovered." In a letter dated March 11, EPA indicated that..."The estimate of 10,000 lb of dissolved phase chlorobenzene in the Bellflower Sand is a "back of the envelope" calculation based on an area to be treated of 160,000 square feet, an estimated thickness of Bellflower Sands of 25 feet, an assumed porosity of the sand of 0.33, and an assumed dissolved-phase concentration of 100,000 micrograms per liter (ug/L)." The basis for the mass estimate was provided in a letter dated March 11, 2010.*

#### **Montrose Response**

Montrose does not agree with EPA's estimated mass of MCB within the BFS subject to potential remediation by a hot floor as part of DNAPL RA 5A. Montrose estimates that there is approximately 2,600 pounds of MCB dissolved in groundwater within the BFS hot floor footprint for RA 5A. Even using the following conservatively high assumptions, less than 27% of the MCB mass estimated by EPA occurs in the dissolved-phase within the hot floor footprint:

$$\text{Mass} = A * h * \phi * C * CF = 2,640 \text{ pounds}$$

Where,

- Area (A) = 70,000 square feet; the footprint of the hot floor for RA 5A is approximately 70,000 square feet, not 160,000 square feet, as shown in Figure 5.17 of the draft DNAPL FS.
- Thickness (h) = 25 feet

- Average Porosity ( $\phi$ ) = 38.8%; the average porosity of the BFS is 38.8%, not 33%, as indicated in Section 4.2.1.2 of Final RI Report, EPA, May 1998
- Average MCB Concentration (C) = 62,250 ug/L; based on March 2008 results from monitoring well BF-9
- Unit Conversion Factor (CF) = 6.24E-8 ([L-lbs]/[cu ft-ug])

The average MCB concentration in the BFS within the hot floor footprint is less than 100,000 ug/L. The only BFS monitoring well occurring within the footprint is BF-9, and this well was last sampled in March 2008 using four passive diffusion bag (PDB) samplers. MCB was detected at concentrations from 28,000 to 79,000 ug/L and at an average concentration of 62,250 ug/L. There are 5 other BF wells/samples at the Montrose Property and within or immediately downgradient of the DNAPL extent as follows:

- BF-2: 33,000 to 53,000 ug/L in March 2008 by PDB samples; average of 46,000 ug/L; 87,000 ug/L in April 2009
- BF-3: 6,100 ug/L in October 2006
- BF-4: 13,000 to 21,000 ug/L in March 2008 by PDB samples; average of 18,000 ug/L
- BFSB-1: 19,000 to 100,000 ug/L in May 2008 by SimulProbe samples; average of 75,000 ug/L
- BFSB-2: 20,000 to 45,000 ug/L in May 2006 by SimulProbe samples; average of 31,000 ug/L

Erroneous assumptions for both area and MCB concentration resulted in EPA's overestimation of MCB mass in the BFS within the hot floor footprint identified for steam injection RA 5A.

### **EPA Comment**

*Continuity of Basal Layer in the UBA: In General Comment No. 3, EPA indicated that... "Specifically, the presence of the 10-foot basal silt layer at the bottom of the UBA needs to be demonstrated and assessed by additional analysis... We have a similar concern about the continuity of the basal silt layer providing separation between the UBA and the BFS... Thus, even if there were a continuous silty sand at the base of the UBA, the DNAPL can penetrate silty sands, and this layer cannot be expected to protect the Bellflower sands from DNAPL contamination during an HD remedy".*

### **Montrose Response**

EPA has misinterpreted the results of the HD modeling and references to the basal layer of the UBA. EPA refers to the basal layer in the UBA as "silt", which is incorrect. The basal layer of the UBA consists of silty sand as consistently indicated in the DNAPL FS... "the basal silty sand layer in the UBA" (e.g., Section 2.6.4). This silty sand layer is present in every boring drilled past 100 feet within the DNAPL-impacted area but in varying thicknesses. Review of the boring logs indicates that the silty sand layer occurs between 93 and 101 feet bgs and varies in thickness between 8 and 23 feet. This layer is a transition between the lower permeability layers of the UBA and the more permeable sand of the BFS. Reference to the basal layer in the DNAPL FS did not imply that the basal layer was more confining than the layers above it. In fact, the basal layer contains higher percentages of sand than the low permeability layers of the UBA.

The significance of this layer as presented in the DNAPL FS was that it is the bottom layer in the UBA. HD modeling did not show any DNAPL passing the bottom layer of the UBA, or in other words, entering the BFS. Montrose did not intend to portray the basal layer as being more confining or lower permeability. No DNAPL passing the bottom layer means that DNAPL did not migrate to the BFS during HD modeling as indicated in Section 2.6.4 of the draft DNAPL FS:

*“Even under these conservative assumptions, the model predicted that DNAPL would not penetrate through the basal silty sand layer of the UBA and into the underlying BFS. Therefore, the potential for DNAPL downward migration into the underlying BFS as a result of hydraulic displacement appears to be minimal, if any, based on these modeling results.”*

## Comments Related to Uniqueness of Montrose DNAPL

### EPA Comment

*Uniqueness of Montrose DNAPL and Challenges for Thermal Remediation: In General Comment No. 2, EPA indicates that..."Monochlorobenzene (MCB) is a relatively common industrial pollutant with a lower boiling point than creosote, which for example, was successfully removed at the Visalia Pole Yard site."*

*In Specific Comment No. 19, EPA indicated that..."Montrose was not the only producer of DDT in the United States. As referenced in the document, DDT was produced at the Arkema site in Portland, Oregon. A mixed DDT/MCB DNAPL is also present at the Velsicol Superfund Site in EPA Region 5, a site that was not mentioned in the text. The occurrence of Montrose DDT/MCB DNAPL may be limited, but not entirely unique. The statements in the FS regarding the "exceptionally limited basis from which to evaluate DNAPL remedial action" are overstated. A suite of chlorinated benzenes, including MCB was successfully treated in DNAPL/sludge at a site in Taunton, Massachusetts, using thermal treatment (conduction heating); an MCB solvent area was also recently treated at Kelly Air Force Base using ERH. Neither site was mentioned in this section. As a fairly common industrial contaminant, a detailed study of sites on the National Priorities List (NPL) and those regulated at the state level would likely reveal more sites with MCB as a component of DNAPL undergoing treatment."*

*In Specific Comment No. 22, EPA indicated that..."Creosote has been successfully recovered using steam injection at the Visalia Pole Yard in California and the Port of Ridgefield in Washington. The most volatile component of creosote is generally naphthalene, which has a boiling point of approximately 220° C. Results from Visalia show that constituents with boiling points up to 340° C (i.e. phenanthrene) can be recovered using steam injection. Typically, constituents are removed preferentially in order of relative boiling temperature; mixtures of different contaminants do not generally present unique challenges with respect to recovery. At the Eastern Woolen Mills site, a low temperature ex-situ thermal desorption remedy was used to treat soils contaminated with mono-, di- and tri-chlorobenzenes. The dichlorobenzenes have boiling points around 170° C, the trichlorobenzenes around 220° C. Despite these high boiling points and the fact that only moderate temperatures were used, soil concentrations of all chlorobenzenes were reduced substantially."*

*In Specific Comment No. 23, EPA indicated that..."We agree that thermal remediation of creosote, a nonvolatile DNAPL, has been successfully demonstrated and that displacement is a primary mechanism for removal of the material during treatment. In the case of MCB, however, both displacement and volatilization forces will be present during steam injection, suggesting that MCB is actually a far better candidate for thermal treatment than creosote."*

### Montrose Response

The Montrose DNAPL is unique; only two other sites in the entire country have been identified as having a similar DNAPL, neither of which have had any thermal remediation testing or full-scale applications of thermal technologies:

Arkema Site: No thermal remediation bench or field pilot testing has been conducted at the Arkema Site in Portland, Oregon, and thermal remediation is not being considered for the site. A containment remedy with groundwater extraction and treatment is being considered for the site (Focused Feasibility Study, ERM, 2008), and in-situ chemical oxidation has previously been field pilot tested within the DNAPL-impacted area.

Velsicol Site: No thermal remediation bench or field pilot testing has been conducted at the Velsicol Site in St. Louis, Michigan. A containment remedy is already in place for the primary

DNAPL source area (OU1), but the remedy is not effective as contaminants continue to leach into groundwater below the slurry wall (Third 5-Year Review Report, EPA, 2007). A feasibility study is currently under preparation for OU1 but is not scheduled to be completed until Fall 2010.

While there are two other sites with similar DNAPLs, they do not offer any evidence in evaluating the potential effectiveness of thermal remediation at the Montrose Site.

Thermal Remediation Effectiveness: EPA may misunderstand Montrose's concerns regarding the potential effectiveness of thermal remediation at the Site. Montrose is not disputing that thermal remediation has the potential to volatilize the MCB-component of the DNAPL. As indicated in the FS, MCB is a volatile organic compound with a boiling point of 132°C, and between 57% and 64% of the MCB mass was removed during 2-D bench testing following 3.4 to 5.4 pore volumes of steam flushing. However, Montrose disputes EPA's estimates of thermal remediation effectiveness and MCB mass removal. In the January 2010 comments, EPA has estimated that thermal remediation could remove up to 94% of the MCB mass. During development of the FS, EPA estimated that thermal remediation could remove up to 99% of the MCB mass or more. EPA additionally requested that Montrose assume only two to three soil pore volumes of steam flushing in estimating costs for steam injection remedial alternatives. Specifically, Montrose contends that:

- A high mass removal efficiency is not an appropriate assumption for the Montrose Site;
- A low energy demand equivalent to only two to three soil pore volumes of steam flushing is not an appropriate assumption for the Montrose Site.

A lower mass removal efficiency and higher energy demand would be more appropriate assumptions for the Site. The nature of the Montrose DNAPL combined with the complex lithology and DNAPL architecture of the Site will (a) reduce the MCB mass removal efficiency as compared with other sites exhibiting different lithology, architecture, and contaminants, and (b) increase the energy demand required to achieve that mass removal efficiency. Montrose's rationale is summarized as follows:

- MCB has a higher boiling/co-boiling point than many other VOCs (e.g., TCE);
- MCB also has a lower vapor pressure than many other VOCs (e.g., TCE);
- The UBA is a highly layered, heterogeneous, and relatively low permeability aquitard, which is not conducive to steam injection (i.e., poor steam distribution, higher reliance on conductive heating, increased number of pore volume flushes required);
- The DNAPL occurs at varying depths over a relatively large area, often as thin occurrences of ganglia (i.e., lower mass removal efficiency and higher number of pore volume flushes to heat).
- The DDT component of the DNAPL slightly raises the boiling and co-boiling points of the MCB component.
- Precipitation of the DDT component during a thermal remedy may foul soil pores, reducing the effective permeability of the thermal treatment zone and the ability for steam and MCB vapors to be transmitted through that zone.

#### **Thermal Remediation Case Sites Referenced by EPA**

To estimate the potential effectiveness of thermal remediation at the Montrose Site, the performance of thermal remediation at other sites was reviewed. Montrose and EPA conducted independent evaluations of thermal remediation experience at 119 and 177 sites respectively (CH2MHill, November 9, 2007).



Montrose contends that EPA's estimate of thermal remediation performance at the Montrose Site is not based on sites with similar contaminants under similar geologic settings. The thermal remediation case sites referenced by EPA in the above comments do not provide any evidence to estimate thermal remediation effectiveness at the Montrose Site as indicated below.

### **Eastland Woolen Mill Site**

While thermal remediation was used to treat MCB in soil at the Eastland Woolen Mill Site in Corinna, Maine, the experiences at that site do not provide any evidence which can be reliably used to predict thermal remediation performance at the Montrose Site as follows:

- **Thermal Remediation Methodology:** Thermal remediation at the Eastland Woolen Mill Site was ex-situ, not in-situ. Soils were excavated and thermally treated in aboveground, enclosed, metal containers, which significantly enhanced the soil porosity, soil permeability, and heat distribution. The soil at the Eastland Woolen Mill Site was placed through a screen to break up and intentionally fluff the soil. The pilot test report indicated that this process was crucial to ensuring even air flow and successful remediation (Final Pilot Study and Performance Test Results Report, 2003). The ex-situ thermal treatment of excavated soils in metal containers at the Eastland Woolen Mill Site does not reasonably simulate the in-situ thermal treatment of saturated soils in a complex and heterogeneous geologic setting at the Montrose Site.
- **Contaminant Concentrations:** The average pre-remediation MCB concentration at the Eastland Woolen Mill Site was only 3 mg/kg as compared with up to 81,000 mg/kg MCB at the Montrose Site. The pre-remediation MCB concentration at the Eastland Woolen Mill Site was exceptionally low and significantly below current soil screening levels (i.e., this concentration of MCB would not even require treatment). Ex-situ thermal remediation of soils containing exceptionally low concentrations of MCB at the Eastland Woolen Mill Site does not provide any evidence for estimating the performance of in-situ thermal remediation of a DNAPL-impacted aquitard at the Montrose Site.

An ex-situ thermal remediation technology to treat soils containing exceptionally low levels of MCB at the Eastland Woolen Mill Site does not provide any basis for estimating thermal remediation performance at the Montrose Site.

### **Taunton Site**

While thermal remediation was used to treat a DNAPL sludge containing chlorinated benzenes at the Route 44 Site in Taunton, Massachusetts, conditions were significantly different from the Montrose Site as follows:

- **Thermal Remediation Technology:** The Taunton Site was treated using ISTD (conductive heating) by TerraTherm, which is a technology not being considered for the Montrose Site because of the likelihood that significant amounts of acid gases would be produced.
- **Treatment Volume:** The thermal treatment area at the Taunton Site was only 5,300 cubic yards, which is significantly smaller than the 44,000 to 267,000 cubic yards being considered for the Montrose Site (Phase IV Remedy Status Report, Geosyntec, 2009).
- **Treatment Depth:** The Taunton Site was treated to a depth of only 16 feet and only 1 foot below the water table, while depths of 60 to 105 feet (all below the water table) are being considered for the Montrose Site.

- **Soil Type:** The soil in the thermal treatment zone at the Taunton Site was described as a sandy fill and sand, while a layered, low permeability aquitard is being considered for the Montrose Site.
- **NAPL Type:** The Taunton Site was impacted with a viscous NAPL identified as a “tarry waste” containing naphthalene, toluene, xylenes, chlorobenzene, 1,2-dichlorobenzene, and 1,2,4-trichlorobenzene. The majority of the contaminant mass removal at the Taunton Site occurred as liquid-phase NAPL recovery (60%), while the majority of contaminant mass removal at the Montrose Site would occur as vapor-phase recovery.

Although contaminant concentrations in shallow unsaturated soils were successfully reduced, **the thermal treatment at the Taunton Site resulted in lateral and downgradient migration of liquid-phase NAPL.** In a report entitled *Phase IV Remedy Status and Monitoring Report* (Geosyntec, February 2007), NAPL was reported downgradient of the thermal treatment zone after 4 months of heating. NAPL thicknesses of 0.5 to 8 feet occurred in three of five downgradient dual-phase extraction wells located approximately 25 feet from the thermal treatment area, in areas where NAPL had not been previously observed. Geosyntec reported that “*the elevated temperatures created as part of the thermal remedy likely reduced the viscosity of the NAPL, making it more mobile in the subsurface*”. Since ISTD does not involve a displacement mechanism, it is reasonable to assume that lateral contaminant migration at the Taunton Site would have been greater if steam injection were implemented at the site. Although ISTD is not a candidate RA for the Montrose Site, this site illustrates the significant risks associated with contaminant migration outside the thermal treatment zone.

Dissolved-phase contaminant concentrations additionally increased in downgradient monitoring wells located between 100 and 150 feet from the thermal treatment area. Dissolved MCB concentrations increased following thermal treatment by 180% to 320% as shown below (Phase IV Remedy Status Report, Geosyntec, August 2009):

Monitoring Well	Contaminant Concentrations in Groundwater (ug/L)											
	MCB		1,2-DCB		1,2,4-TCB		Naphthalene		Toluene		Xylenes	
	2006	2009	2006	2009	2006	2009	2006	2009	2006	2009	2006	2009
YH-03 Shallow	13	<200	16	260	330	5,400	31	1,200	74	260	560	4,800
YH-10 Shallow	4,300	12,000	8,900	6,000	64,000	8,800	31,000	3,800	24,000	48,000	21,000	13,900
YH-11 Shallow	1,200	5,000	3,000	14,000	8,400	22,000	2,900	16,000	26,000	95,000	2,000	13,300

**Notes:**

2006 = July 2006; prior to start of thermal remedy

2009 = April 2009; most recent groundwater monitoring results

ug/L = Micrograms per liter

MCB = Monochlorobenzene

DCB = Dichlorobenzene

TCB = Trichlorobenzene

ISTD was used to treat shallow, sandy, and primarily unsaturated soils containing a dissimilar viscous sludge over a small area, and therefore, MCB mass removal efficiencies at the Montrose Site cannot be estimated using the data from the Taunton Site. Furthermore, uncontrolled lateral migration of NAPL and dissolved-phase contaminants occurred at this site following thermal treatment.

### **Kelly AFB**

While ERH is being used to treat chlorinated benzenes in soils at the Kelly Air Force Base (AFB) in San Antonio, Texas, the experiences at that site will not provide any evidence which can be reliably used to predict thermal remediation performance at the Montrose Site as follows:

- **Status of Thermal Remediation:** In Specific Comment No. 19, EPA indicates that “*an MCB solvent area was also recently treated at Kelly Air Force Base*”. This is not correct. The remedial design and implementation plans for the S-1 Site were being finalized in January 2010, and startup of the ERH system is not expected to occur prior to May 2010 (Final Technical and Management Work Plan, Cape, January 2010). An ERH remediation was recently completed, in August 2009, at the Building B301 Site at the Kelly AFB, where soils were primarily impacted with PCE but no chlorinated benzenes.
- **Treatment Volume:** The treatment volume at the S-1 Site is approximately 11,000 cubic yards, while 44,000 to 267,000 cubic yards are being considered for the Montrose Site. The treatment area was based on chlorobenzene concentrations exceeding 5,000 ug/L in groundwater.
- **Treatment Depth:** The treatment depth at the S-1 Site is from 15 to 35 feet bgs, with groundwater levels fluctuating between 23 and 34 feet bgs since 2005 (due to drought conditions). By comparison, the treatment depth at the Montrose Site is 60 to 105 feet bgs, all below the water table.
- **Soil Type:** The thermal treatment zone and alluvial aquifer consists of gravel and clayey gravel, while the soil type at the Montrose Site is a layered, heterogeneous, and low permeability aquitard.
- **Confining Layer:** The alluvial aquifer at the S-1 Site is underlain by the Navarro Clay Aquitard. The DNAPL-impacted area at the Montrose Site is underlain by the Bellflower Sand Aquifer.
- **Contaminant Type and Concentrations:** The maximum detected chlorobenzene concentration in soil at the S-1 Site is 580 mg/kg. This concentration is below the current EPA industrial Regional Screening Level (RSL) for chlorobenzene of 1,400 mg/kg and is significantly below the maximum concentration of chlorobenzene detected in soils at the Montrose Site (81,000 mg/kg). Furthermore, the chlorobenzene at the S-1 Site occurs in a low density oil (LNAPL) which has been smeared throughout the lower vadose zone by the fluctuating water level. The ERH work plan stated that “no separated chlorobenzene free product is expected to be present at Site S-1”. At the Montrose Site, the chlorobenzene is a 50% component of the DNAPL occurring below the water table.

The ERH remedy at the Kelly AFB S-1 Site will treat shallow, gravelly, and primarily unsaturated soils containing low concentrations of MCB dissolved in a low density oil (LNAPL) over a small area, and therefore, this site will not provide any evidence for estimating thermal remediation performance at the Montrose Site.

### **Creosote Sites**

Thermal treatment of creosote-impacted sites does not provide any reliable evidence for estimating MCB mass removal efficiencies at the Montrose Site. Although thermal remediation is applied to creosote-impacted sites, the primary mass removal mechanism is displacement of liquid-phase NAPL, with vapor-phase removal as a secondary mechanism (with the possible exception of ISTD). Creosote has a

relatively low mobility under standard conditions, and steam injection is applied to mobilize these contaminants for removal in the liquid-phase (i.e., similar to hydraulic displacement). Higher temperatures are achieved with ISTD enabling a greater degree of volatilization than would normally be possible under steam injection. However, the Montrose DNAPL is not as viscous as creosote and is mobile under standard conditions. Heating of the subsurface is not required to recover mobile DNAPL at the Montrose Site via hydraulic extraction/displacement. Additionally, the density of creosote is close to that of water, and when heated, can become an LNAPL. As either a neutral density NAPL or a lighter-than-water NAPL, heated creosote poses a significantly lower vertical migration risk as compared to the Montrose DNAPL (i.e., the capillary pressure at the base of an accumulating NAPL bank is a function of the NAPL density). The mechanisms for thermal remediation of creosote sites are fundamentally different from that of the Montrose DNAPL, and therefore, do not provide reliable evidence for estimating MCB mass removal efficiencies at the Montrose Site.

The SCE Visalia Site and Pacific Wood Treating Site were both creosote-impacted sites, and these sites were compared against the Montrose Site in the DNAPL FS (Appendix L). As noted in the DNAPL FS, there are significant differences between these sites and the Montrose Site. However, SCE reported that the DNAPL-impacted aquifer at the Visalia Site was treated using approximately 8 pore volumes of steam flushing, which is significantly more steam flushing than recommended by EPA for the Montrose Site (2 to 3 pore volumes).

## Comments Related to DNAPL Mass Estimates

### EPA Comment

*DNAPL Mass in the UBA: In Specific Comment No. 4, titled DNAPL Mass in the Saturated Zone is Overestimated, EPA indicates that... "For the overall DNAPL area, this approach results in an estimate of MCB mass of 291,000 pounds (lbs) (582,000 lbs of DNAPL), which is smaller than, but not grossly different from the estimate of 398,000 lbs of MCB (796,000 lbs of DNAPL) provided in the FS.*

*In Specific Comment No. 9, EPA indicates that... "The total estimate of MCB mass in the entire source area is 291,000 lbs, of which 245,000 lbs is in the focused treatment area (84 percent)".*

*In Specific Comment No. 4, EPA indicates that... "Throughout the Montrose property, the FS estimates the mass of mobile MCB to be 111,000 lb (222,000 lbs of DNAPL), which appears to be an overestimate of mobile DNAPL and MCB. The alternate approach used by EPA produces an estimate of 40,000 lbs of mobile MCB (80,000 lbs of DNAPL), which is less than half of that estimated in the FS."*

*In Specific Comment No. 4, EPA indicated that they would provide Montrose with the basis for the DNAPL mass calculations. The basis for the calculations was subsequently provided in a letter dated March 11, 2010.*

### Montrose Response

During development of the DNAPL FS, EPA commented that Montrose's estimate of DNAPL mass was underestimated, not overestimated. In comments dated December 23, 2008, EPA indicated that... "we believe that even the upper-end estimate is likely to be too low by a significant amount", and that "the conservative estimate of mass may be locally in error by as much as a factor of 20 times, not by a factor of 2 times".

During development of the FS, Montrose had considered a low or "conservative" DNAPL mass estimate of 375,000 pounds and a high or "liberal" DNAPL mass estimate of 796,100 pounds. Although there is a considerable amount of uncertainty associated with the mass estimates, Montrose estimated that between 375,000 and 796,100 pounds of DNAPL is present at the Site. Based on EPA's comments during development of the FS, the conservative DNAPL mass estimate was excluded and only the liberal mass estimate was presented in the FS. Similarly, the following statements were included in the FS to address EPA's concerns that Montrose may have underestimated the DNAPL mass:

*Given the uncertainty associated with DNAPL thickness and concentrations, the DNAPL mass could be as much as 50% higher or up to 1.2 million pounds. However, comparing the liberal thickness estimates against theoretical thickness amounts (determined using DNAPL concentrations and capillary pressure data), the liberal thickness estimates appear to be overestimated, if anything, in approximately two-thirds of the DNAPL occurrences (H+A, 2009c). Therefore, the DNAPL mass estimate is not believed to be significantly underestimated as suggested by EPA in comments made in a letter dated December 23, 2008 (EPA, 2008g).*

Since the liberal mass estimate was intended to reflect a reasonable high range, Montrose does not object to a DNAPL mass estimate of 582,000 pounds which is (a) lower than Montrose's liberal estimate, (b) between the range previously estimated by Montrose, and (c) very close to the average of Montrose's estimated DNAPL mass range (585,500 pounds). Montrose notes that EPA's estimate of DNAPL mass within the focused treatment area of 490,000 pounds is also very close to Montrose's estimate of 473,600 pounds (only a 3% difference).

However, EPA has used an alternate method to estimate DNAPL mass, and following review of the documentation provided in EPA's March 11, 2010 letter, Montrose does have concerns regarding the accuracy of EPA's mass estimate. Montrose acknowledges the technical challenges in estimating DNAPL mass and recognizes that any mass estimate will involve some data interpretation and uncertainty. With that in mind, Montrose believes there are some errors and several incorrect assumptions associated with EPA's mass estimate methodology as described below.

#### **Accuracy of EPA DNAPL Mass Estimate**

EPA's calculations of DNAPL mass at the Montrose Site assumed that the MCB concentrations were reported on a dry weight basis, which is incorrect. Also, there were issues with the area assumed for the focused treatment area as described below.

**Corrected DNAPL Mass Integral:** Although the 2-D bench testing results were reported on a dry weight basis, the DNAPL Reconnaissance Investigation samples were analyzed on a wet weight basis using modified EPA Method 8270C. The peak MCB concentration detected at each DNAPL investigation boring was used to estimate DNAPL mass as shown in Appendix E of the DNAPL FS. EPA used the wet weight MCB concentrations from Table E-2 and a dry weight soil density, resulting in an erroneously low estimate of DNAPL mass. A corrected DNAPL mass integral (in grams per square foot) versus MCB concentration is presented in **Figure 4** along with EPA's mass integral curve. The impact of the soil density error is low at low DNAPL concentrations but increases at increasing DNAPL concentrations (diverging curves). A comparison of the DNAPL mass integrals for the two soil densities is provided as follows:

DNAPL Mass Estimate	DNAPL Mass Integral (grams per square foot)		
	MCB = 15,000 mg/kg	MCB = 30,000 mg/kg	MCB = 50,000 mg/kg
EPA Estimate – Jan 2010	420	1,220	2,920
Corrected EPA Estimate	570	1,720	4,330

**Focused Treatment Area:** EPA assumed a focused treatment area of 30,492 square feet to estimate DNAPL mass, which is not correct. The size of the focused treatment area was defined as 26,000 square feet as indicated in Section 5.1.5 and shown in Figure 5.11 of the DNAPL FS. The size of the focused treatment area was based on DNAPL concentrations exceeding 53,000 mg/kg, which is equivalent to a residual DNAPL saturation of 18.9% on a wet weight basis. EPA's focused treatment area is 17% larger and is based on DNAPL concentrations exceeding 50,000 mg/kg or 17.9% residual DNAPL saturation. The larger area used by EPA resulted in an overestimation of the DNAPL mass within the focused treatment area.

**Mobile DNAPL Mass Estimate:** EPA estimated a mobile DNAPL mass of 80,000 pounds based on a residual DNAPL concentration of 64,000 mg/kg (MCB concentration of 32,000 mg/kg), which is incorrect. DNAPL concentrations were reported on a wet weight basis during DNAPL investigation activities, and an 18.9% residual saturation is equivalent to an MCB concentration of approximately 53,000 mg/kg on a wet weight basis.

Using the corrected mass integral, focused treatment area, and residual DNAPL concentrations, the DNAPL mass using EPA's methodology is estimated as follows:

DNAPL Mass Estimate	Estimated DNAPL Mass (pounds)		
	Entire DNAPL-Impacted Area	Focused Treatment Area	Mobile DNAPL Mass
EPA Estimate – Jan 2010	582,000	490,000	80,000
Corrected EPA Estimate	842,000	610,000	143,500
Montrose DNAPL FS – Apr 2009	796,100	473,600	221,800

- The wet weight corrected EPA DNAPL mass estimate for the entire DNAPL-impacted area is within 6% of the Montrose mass estimate. The corrected EPA DNAPL mass calculation is attached as **Table E-2B**.
- The corrected EPA DNAPL mass estimate for the focused treatment area is 29% higher than the Montrose mass estimate. The corrected EPA DNAPL mass calculation is attached as **Table E-3B**.
- The corrected EPA mobile DNAPL mass estimate is 35% lower than the Montrose mass estimate. The corrected EPA mobile DNAPL mass calculation is attached as **Table E-4B**.

EPA has used the DNAPL investigation data in a manner for which it was never intended, and as a result, misrepresents the distribution of DNAPL at the Site. Specific concerns regarding EPA's mass estimate methodology are presented below:

- EPA has only used the analytical results from the DNAPL investigation activities to estimate DNAPL mass. In doing so, any inadequacies in the analytical sampling program will be magnified by this approach. The objective of the DNAPL Reconnaissance Investigation was to assess the presence of DNAPL, and laboratory analysis of soil samples was a secondary line of evidence in determining DNAPL presence which was performed in accordance with an EPA-approved workplan. Quantification of DNAPL mass through detailed laboratory analysis was not an objective of the investigation program.
- Between one and four soil samples were collected per boring, typically from different depths or possible DNAPL occurrences. Detailed sampling within the same DNAPL pool was not conducted, and there were a number of DNAPL occurrences which were not sampled at all.
- EPA has assumed that DNAPL occurs only once at each boring, which is not true. DNAPL was found to typically occur between one and seven times at each soil boring. EPA's methodology only accounts for one occurrence of DNAPL at each boring, resulting in an underestimation of DNAPL mass.
- EPA has assumed that the soil samples were collected at the very base of a DNAPL pool, which is not true. There was no protocol in the DNAPL Reconnaissance Investigation to only collect samples from the base of a potential DNAPL pool. The soil sampled for laboratory analysis was selected at the discretion of the field geologist and was intended to coincide with possible occurrences of DNAPL. Each soil sample contained only 5 grams of soil, which is equivalent to a sample volume of less than 3 cubic centimeters. Every 6 vertical inches of 4-inch diameter core

contained enough soil to collect over 400 samples. EPA's assumption results in an underestimation of DNAPL mass at the Site since the highest concentrations of DNAPL may have been missed by the sampling program. Montrose has assumed that the analytical result is representative of the estimated DNAPL thickness, and therefore, would be representative of the mean DNAPL concentration across that thickness (instead of maximum concentration). This is a more reasonable and accurate assumption given the protocols for the investigation.

- EPA's methodology assumes that DNAPL occurs in uniform sands with sufficient thickness to accommodate the maximum pool height, which is not true. DNAPL occurs in sand layers with varying physical properties, varying percentages of fines, and varying thicknesses. Except at the base of the UBA, the sand layers are typically confined between two low permeability silt layers. The theoretical assumptions associated with EPA's methodology do not closely match the geologic setting and DNAPL architecture of the Site. In some cases, the theoretical DNAPL pool height calculated using EPA's methodology exceeds the thickness of the sand layer in which the DNAPL has accumulated.
- EPA only used MCB concentrations in estimating DNAPL mass. EPA has only used the peak MCB concentrations in estimating DNAPL mass at each boring and subsequently multiplied the estimated MCB mass by two in order to report DNAPL mass. In doing so, only half of the analytical results were used, and EPA has unnecessarily introduced error into the mass estimate when Total DDT concentrations were reported coincidentally with MCB using modified EPA Method 8270C. While the composition of the Montrose DNAPL has been documented through analysis, soil sample results from DNAPL investigation activities did not reflect a 50/50 contribution at every boring. Examples include:

Boring ID	Concentration in Soil (mg/kg)			EPA DNAPL Mass Estimate
	MCB	Total DDT	DNAPL	
S-101/101A	36,000	51,000	87,000	Will underestimate DNAPL mass
S-304/304A	4,900	69,000	73,900	Will significantly underestimate DNAPL mass
S-305/305A	81,000	24,000	105,000	Will overestimate DNAPL mass

The overall average of the peak concentrations results in contributions of 51% MCB and 49% Total DDT. Therefore, using the DNAPL concentration (as Montrose did) will result in a more reliable estimate than using only the MCB concentration (as EPA did). EPA's approach effectively uses a DNAPL concentration of 162,000 mg/kg at boring S-305/305A, which is 54% higher than the actual value reported by the laboratory. Similarly, EPA's approach effectively uses a DNAPL concentration of 9,800 mg/kg at boring S-304/304A, which is 87% lower than the actual value reported by the laboratory.

- EPA has assumed an average DNAPL mass integral of 3,651 grams per square foot for the area inside the 50,000 mg/kg DNAPL concentration contour (30,492 square feet). On a dry weight basis, this mass integral is equivalent to an average initial MCB concentration of 56,400 mg/kg as shown in Figure 2 of EPA's March 11, 2010 letter. Under EPA's approach, the equivalent average DNAPL concentration for this area was assumed to be 112,800 mg/kg, which is higher than all DNAPL concentrations reported during the DNAPL Reconnaissance Investigation and does not compare favorably because of the error in the soil density assumption. It is not appropriate to estimate DNAPL mass using concentrations outside of the range over which DNAPL occurs at the Site.



- The bulk of EPA's DNAPL mass estimate is based on a very small data set. **85% of EPA's mass estimate is based on the MCB concentrations from eight soil samples.** Due to the exceptionally small data set, EPA's methodology misrepresents the distribution of DNAPL at the Site. In comparison, visual evidence, FLUTE ribbon staining, soil headspace, laboratory results (MCB and Total DDT), soil type, and professional judgment were all factored into consideration as part of Montrose's mass estimate.

Although EPA's methodology accounts for a concentration profile vertically within DNAPL pools, the numerous erroneous assumptions significantly reduces the accuracy and reliability of EPA's DNAPL mass estimates. Consequently, the DNAPL mass estimates presented in the FS are more accurate and reliable than those presented by EPA. However, if the erroneous assumptions were fully corrected, then the methodology proposed by EPA could be used to reasonably estimate DNAPL mass at the Site.

## Comments Related to Mass Flux Evaluation

### EPA Comment

*Mass Flux Evaluation (Section 2.6.1 of the DNAPL FS): In Specific Comment No. 32, EPA is concerned about the applicability of the Falta et. al. (2005) method to the DNAPL-impacted UBA and indicates that... "this approach is limited to application to systems with horizontal flow". EPA believes that the flow through the UBA is primarily vertical, not horizontal, and indicates that... "estimates of groundwater fluxes performed with the RD numerical groundwater model of the site indicate that the flow within UBA beneath the Montrose property is primarily vertical, rather than horizontal. These estimates are also consistent with the aquitard nature of this hydrostratigraphic unit, and with the observed limited lateral extent of the MCB and p-CBSA distributions within the UBA, and the significant vertical extent of these distributions." EPA additionally indicates that... "Under ambient conditions, the dominant direction of groundwater flow in the UBA is vertically downward to the underlying BFS (within the 400-foot by 400-foot source area, the RD model indicates a horizontal flow rate of 5 cubic feet per day [ft<sup>3</sup>/day] and a vertical flow rate of 25 ft<sup>3</sup>/day)."*

*EPA also believes that the mass flux evaluation should be based on achieving a cleanup goal of 70 ug/L in the BFS, not the overlying UBA. In Specific Comment No. 32, EPA indicates that... "Given the limited horizontal movement of groundwater in the UBA, the limited permeability of the UBA, and the much higher rate of horizontal flow in the underlying BFS (980 ft<sup>3</sup>/day through the source area), the migration of the dissolved-phase plume is controlled almost entirely by concentrations in the BFS... Based on a simple mass balance calculation, a concentration of 70 µg/L in the BFS at a horizontal flow rate of 980 ft<sup>3</sup>/day would result from a vertical flux of 25 ft<sup>3</sup>/day from the overlying UBA at a concentration of 2,744 µg/L... Using a target MCB concentration of 2,744 µg/L would reduce the source longevity estimates."*

*EPA additionally believes that a lower effective solubility should be used for MCB in the mass flux evaluation. In Specific Comment No. 32, EPA indicates that... "the MCB is part of a multi-component DNAPL with DDT, with MCB comprising about 50 percent of the DNAPL. Application of Raoult's Law results in an effective solubility of about half that of the pure-phase solubility, or about 205 mg/L. Use of the lower effective solubility to account for the DDT component would increase the longevity estimate of the source zone."*

### Montrose Response

#### Dominant Groundwater Flow Direction in UBA

The dominant groundwater flow direction in the UBA is horizontal, not vertical as EPA suggests in their comment. While the Groundwater RD model reasonably simulates flow conditions on a large scale across the model domain, it does not accurately simulate the ratio of horizontal to vertical flow in the UBA at the Montrose Property. Simplifying assumptions were incorporated into the RD model, which are not consistent with Site conditions at the local scale as follows:

- The UBA was represented as a single layer in the RD model. The RD model does not simulate the multi-layered nature of the UBA, interbedded sands and silts, or account for heterogeneities.

- The ratio of horizontal to vertical permeability ( $K_h/K_v$ ) was fixed throughout the UBA layer at the same value as the BFS (i.e., 10). Although this assumed  $K_h/K_v$  value allowed calibration of the model on a regional scale, it is unrealistically low given the lithology of the UBA. Therefore, the model simulated proportionally too much water to move vertically downward from the UBA to the BFS beneath the Montrose Property.
- The model specified recharge (essentially from land surface) within the DNAPL source area, which is not consistent with the paved surface of the Montrose Property. While the amount of recharge results in conditions that are regionally representative of groundwater flow, it results in locally excessive vertical downward flow in the modeled UBA layer.

Although the vertical component of the hydraulic gradient used in the mass flux evaluation (0.027) is approximately 10 times greater than the horizontal component of the hydraulic gradient (0.0025), the dominant flow direction in the UBA is horizontal. The bulk horizontal hydraulic conductivity in the UBA is several orders of magnitude higher than the bulk vertical hydraulic conductivity, which overcomes the one order of magnitude difference in the gradients. As a result, the estimated groundwater velocity in the horizontal direction is 0.13 foot per day while the estimated groundwater velocity in the vertical direction is 0.00043 foot per day. These estimates indicate that the horizontal groundwater velocity is approximately 300 times greater than the vertical groundwater velocity and is the dominant flow direction.

#### Contaminant Distribution as Evidence of Vertical Flow in UBA

The larger distribution of chlorobenzene in the BFS and Gage Aquifers relative to the distribution in the UBA is not persuasive evidence of vertical groundwater flow being the dominant direction in the UBA currently. Reasons provided as follows:

- Historically, wastewater was discharged to an unlined water recycling pond in the Central Process Area (EPA, 1998). Wastewater released to the subsurface would have percolated downward, forming a mound at the water table and increasing the downward vertical gradient. Discharges to the recycling pond have not occurred for more than 40 years, and mounding associated with the former recycling pond is no longer present at the Site.
- During historical plant operations, the regional water level declined to near the base of the UBA, approximately 30 feet deeper than the current water level. Contaminants may have migrated deeper within the UBA as a result of the historically lower water table.
- Downgradient of the Montrose Property, the fine-grained layers of the UBA pinch out, and the overlying B-sand and underlying C-sand merge into a single coarse grained unit (e.g. the BFS). The dissolved chlorobenzene moving laterally downgradient in the UBA migrates into the BFS without having to migrate vertically downward.
- The horizontal flow rate through the BFS is much higher than through the UBA, as indicated in EPA Specific Comment No. 32.

Occurrence of the more extensive chlorobenzene plume in the BFS does not indicate that the predominant flow direction within the DNAPL-impacted UBA is currently downward. Site data indicate that current and likely future flow in the UBA is predominantly horizontal, consistent with the horizontally interbedded nature of the UBA lithology.

### Applicability of Falta Method

The method provided by Falta et al. (2005a) is a peer-reviewed, published, and state of the practice approach that was supported by EPA through the National Risk Management Research Laboratory, and the Strategic Environmental Research and Development Program (SERDP) (Falta, 2005a). A November 8, 2007 EPA presentation titled “Flux-Based Site Management” also identifies the approach presented by Falta et al. (2005a) as a method that can be used for assessing mass flux (EPA, 2007). It is one of the best available methods for evaluating dissolved phase concentrations over time. This is further evidenced by integration of this approach in the REMChlor (**R**emediation **E**valuation **M**odel for **C**hlorinated Solvents) (Falta, 2007) program, which was developed in cooperation with EPA for this purpose. This model was specifically developed for evaluating the benefits of partial mass removal from DNAPL sites. Since the intent of Montrose’s evaluation was to determine the time to achieve the cleanup standard for chlorobenzene immediately downgradient of a continuing source, rather than evaluate downgradient plume behavior, the REMChlor model itself was not used. Instead, the numerical solutions presented by Falta et al. (2005a) were utilized to estimate the time to achieve the cleanup standard for chlorobenzene. Pursuant to personal communication with Dr. Ronald Falta, it was confirmed that it is reasonable to use this approach to estimate dissolution timeframes.

Although groundwater flow at the Montrose Site is predominately horizontal, the method is not solely applicable to horizontal flow. Dr. Ronald Falta confirmed during personal communications that the method utilized in this evaluation (Falta, 2005a) can be used to assess vertical flow systems or, as was done in this evaluation, to consider a primarily horizontal flow system with a small downward component.

### Source Longevity in UBA

The purpose of this evaluation was to assess the timeframes required for hydraulic containment following potential implementation of a DNAPL remedy at the Montrose Site. Long-term hydraulic containment of the DNAPL source area will be required to address chlorobenzene dissolution into groundwater. As EPA indicates, the horizontal flow in the BFS is significantly higher than the UBA and will achieve cleanup goals in advance of the UBA. Since the dominant flow direction in the DNAPL-impacted UBA is horizontal as discussed above, the timeframe for hydraulic containment of the UBA will be the longer than for the BFS. Therefore, it was appropriate to focus this mass flux evaluation on concentrations in the UBA rather than the BFS.

### MCB Solubility

The effective aqueous solubility for chlorobenzene from DNAPL assumed in the mass flux evaluation (410 mg/L) was taken directly from Section 6.2.2.1 of the Final Remedial Investigation (RI) Report (EPA, 1998). The RI Report indicated that...“*the estimated effective aqueous solubility of chlorobenzene from DNAPL would be about 410 mg/L (410,000 ug/L)*”. Although the DNAPL is composed of approximately 50/50 chlorobenzene and DDT on a percent mass basis, the mole fraction is considered when calculating effective solubilities using Raoult’s law, not the percent mass. The molecular weight of DDT (354.49 g/mol) is more than 3 times higher than the molecular weight of chlorobenzene (112.56 g/mol). As a result, the effective multi-component aqueous solubility for chlorobenzene from DNAPL on a mole basis is 410 mg/L. Additionally, chlorobenzene has been detected in groundwater within the UBA in concentrations up to 380 mg/L, demonstrating an effective solubility well above the value of 205 mg/L suggested by EPA in their comment. Additionally, chlorobenzene concentrations between 290 and 390 mg/L were detected in groundwater/steam condensate recovered at the start of 2-D steam injection bench testing.

## Comments Related to HD Modeling

### EPA Comment

*HD Modeling (Section 2.6.4 of the DNAPL FS): In Specific Comment No. 34, EPA is concerned about assumptions associated with the basal layer of the UBA and indicates that..."A critical assumption in the conceptual model applied to the HD modeling of potential vertical migration of DNAPL is that a continuous silt layer of substantial thickness is present at the base of the UBA, separating the UBA from the BFS...In the absence of the continuous basal silt layer at the bottom of the UBA, DNAPL that will be mobilized by HD extraction wells has a potential of migrating downward into the BFS. To assess the continuity of the basal silt layer, a geostatistical analysis of the vertical zone hypothesized to contain the basal silt zone should be conducted."*

*EPA also had concerns regarding the initial conditions assumed in the model. In Specific Comment No. 34, EPA indicates that..."the initial condition specified a DNAPL saturation of 30 percent, with a thickness of only 0.2 foot. This represents a condition where DNAPL saturations are not in equilibrium with the capillary pressures induced by the height of the accumulation and may not be realistic. Specifically, based on a Van Genuchten capillary alpha of 0.01/cm, a DNAPL thickness of approximately 2.4 feet would be required to produce a DNAPL saturation of 0.3 at the base of the zone. A 0.2-foot accumulation of DNAPL would, under equilibrium conditions, produce a maximum DNAPL saturation of 0.001. This likely explains why the DNAPL in the model was laterally mobile without pumping using the Van Genuchten formulations, and continued to be mobile until residual saturation (which was greater than 0.001) was reached. It is possible that the use of the Brooks-Corey formulation, with its explicit entry pressure, would not have been necessary if the initial conditions of DNAPL emplacement had been more realistic. The use of the coarse-grained zone in the area of DNAPL emplacement to establish an artificial entry pressure barrier should not have been necessary. This was likely necessitated by the use of overly high DNAPL saturations for the thickness of accumulated DNAPL in the source area and/or by a relative permeability relation that poorly represented the mobility of the DNAPL at low saturations."*

*EPA believes that the HD modeling underestimated the vertical migration of DNAPL into the basal layer in the UBA. In Specific Comment No. 34, EPA indicates that..."The use of the coarse-grained zone in the area of DNAPL emplacement to establish an artificial entry pressure barrier should not have been necessary...The calculated entry pressure, based on the best-fit Brooks-Corey relationship would be 0.6 pounds per square inch (psi) (42 cm of water), meaning that the capillary pressure would have to exceed 42 cm of water for the DNAPL to displace water and invade the pore space. Yet careful examination of the plot shows that effective water saturations are about 0.975, or DNAPL saturations are about 0.025, at capillary pressures of 0.35 psi (24 cm of water), well below the entry pressure. Therefore, the use of the Brooks-Corey relationship in UTCHEM underestimates the degree to which the DNAPL can invade the basal silt."*

*EPA questions the DNAPL saturations simulated in the coarse-grained zone of the model. In Specific Comment No. 34, EPA indicates that..."The results of the capture radius simulations appear to show DNAPL saturations actually increasing (Figure 6 of the HD Modeling Report) from the initial condition saturations (based on the color scale, there appear to be some cells with 0.4 and even 0.5 saturations in the source area). This is likely a result of the combined use of a coarse-grained zone of emplacement and saturations that are above those in equilibrium with the 0.2-foot thickness of the DNAPL zone."*

## **Montrose Response**

### **Basal Layer Continuity**

As explained in the Montrose response to EPA General Comment No. 3, the basal layer of the UBA was identified as a silty sand, not a silt. The basal silty sand was found to be present in all 11 borings drilled to this depth including:

- 5 borings located within the DNAPL-impacted area (S101A, S301A, S302A, S304A, and S305A);
- 3 borings located on-Property but outside the DNAPL-impacted area (BFSB-1, BFSB-2, and EB-2A); and
- 3 off-Property borings located (BF-34, BF-35, and G-20).

In these 11 borings, the basal silty sand occurred in thicknesses of 8 to 23 feet. Given the substantial thickness and universal presence of the basal silty sand in borings advanced through this interval, it is laterally extensive across the Property including the DNAPL-impacted area. Since the basal silty sand is a continuous layer beneath the UBA at the Property, a geostatistical analysis would not provide any additional insight.

### **Initial Conditions**

The DNAPL pool height specified in the model (i.e., 0.2 foot) is the appropriate pool height for a DNAPL pool with a basal saturation of 30 percent in coarse-grained sand. The DNAPL thickness and saturation numbers cited by EPA (i.e., 2.4 feet and 30 percent) are representative of fine sand, not coarse sand. It was necessary to simulate a local coarse-grained zone in the model to create an adequate reservoir of DNAPL and prevent spontaneous mobilization of the DNAPL within the surrounding fine sand. Since laboratory capillary pressure-saturation data for coarse sand at the Site was not available, the pool height-saturation relationship for the coarse sand was obtained by scaling the laboratory capillary pressure curves obtained for the fine sand using the Leverett function (Corey, 1994; Pope et al., 1999) and is therefore representative of the type of sand specified in the model.

Use of an entry pressure barrier was not necessitated by use of an overly high DNAPL saturation. A DNAPL saturation of 30 percent was utilized in the model, which is greater than the residual saturation of 19 percent. As such, the DNAPL pool specified in the model is “mobile”, and without use of an entry pressure barrier, would move under static (non-pumping) conditions. To overcome this issue, the DNAPL was emplaced in a coarse sand and was surrounded by a fine sand. The entry pressure of the fine sand keeps the DNAPL from moving laterally under static conditions. The DNAPL pool height and saturations were consistent with a coarse sand with a hydraulic conductivity of 45 feet/day. This represents a pool of DNAPL that is in vertical equilibrium within the coarse sand and saturations are not “overly high”.

Further, it was not the use of inappropriate DNAPL pool heights/saturations which allowed DNAPL to mobilize under static conditions when using the van Genuchten relationship. The van Genuchten relationship does not account for the physical process of overcoming the entry pressure prior to DNAPL migrating. The spontaneous mobilization under non-pumping conditions is related to a limitation of the van Genuchten relationship and is not due to specifying an unrealistically high DNAPL saturation and/or pool height. It was for this reason that the modeling approach was amended using the Brooks-Corey relationship which more accurately accounts for entry pressure (H+A and INTERA, 2009). However, even this approach requires that there be an entry pressure difference between the sand where the DNAPL is

emplaced and the surrounding sand. If a uniform sand is used, there is no entry pressure difference between the sand where the DNAPL is emplaced and the surrounding sand. It is impossible to evaluate the effects of pumping on DNAPL mobilization if the capillary pressure of the DNAPL pool is greater than the entry pressure of the surrounding sand. It was for this reason that an entry pressure boundary was used, and it was not related to specifying an inappropriate DNAPL pool height.

#### Vertical Migration

The use of the Brooks-Corey drainage curve does not underestimate the degree to which DNAPL can invade the basal silty sand. The capillary pressure curve referenced by EPA (i.e., Figure 4) is not the appropriate curve for the basal silty sand layer. Figure 4 is the entry pressure relationship based on capillary curves obtained from five sand samples overlying the basal layer, and these data are not representative of the basal silty sand. The basal silty sand is a finer-grained unit with correspondingly higher entry pressures. The capillary characteristic curve for the basal silty sand was scaled from the sand data using the Leveret function. The entry pressure used for the basal silty sand was appropriate given the finer-grained nature of this zone, and therefore, the model does not underestimate the potential for DNAPL to penetrate the basal silty sand. Based on the HD modeling results, a DNAPL pool would have to accumulate in the overlying sand to a height of more than 8 feet in order to exceed the entry pressure of the silty sand at the base of the UBA (H+A and Intera, 2009).

#### DNAPL Saturations in the Modeled Coarse-Grained Zone

DNAPL is initially above residual saturation (19 percent) and is laterally mobile within the modeled coarse sand zone. Once pumping starts, saturations can increase above the initial saturations as the DNAPL is mobilized and redistributed. This redistribution effect is a possibility during an HD remedy and does not imply that saturations are unrealistically high for a DNAPL pool in a coarse sand zone, nor does it imply that the conclusions regarding the ability for DNAPL to enter the adjacent fine sand are invalid.

## **Comments Related to Hydraulic Displacement (RA 4)**

### **EPA Comment**

*Reinjection of Untreated Water under HD: In Specific Comment No. 12, EPA indicates that..."Further, the proposal to reinject untreated groundwater on site would have to be approved by the regulatory agencies. EPA has significant concerns with this proposal which not only defeats the long term purpose of mass removal in remediating the plume, but could further mobilize contaminants, causing the plume to spread. The proposal to reinject untreated groundwater does not comply with RAOs #3 and #6 to contain the groundwater plume and reduce the dissolved phase concentrations over time to the extent practicable."*

### **Montrose Response**

In the document entitled *Responses to EPA Focus Questions Pertaining to the Application of Thermal Treatment and Hydraulic Displacement at DNAPL Sites*, CH2M Hill provided a cost estimate for a hydraulic displacement remedy at the Montrose Site. The CH2M Hill cost estimate assumed that treatment of groundwater prior to reinjection would not be required for the remedy. Montrose discussed this strategy with EPA during subsequent meetings, and during a meeting held on April 15, 2008, EPA agreed to include HD with untreated groundwater reinjection as a candidate alternative to be considered in the FS. Specific Comment No. 12 contradicts prior agreements made between Montrose and EPA during development of the FS.

The rationale for considering reinjection of untreated groundwater was that the primary mass removal mechanism was extraction of separate-phase DNAPL as compared to dissolved-phase. Since the dissolved-phase MCB mass will be small relative to the DNAPL-phase mass, the most cost effective application of the technology would be to reinject untreated groundwater. While this application does not promote further dissolution of MCB from the DNAPL, the relatively high cost of groundwater treatment is eliminated while retaining the benefits of DNAPL-phase mass removal. Additionally, as indicated in Section 4.9.3 of the DNAPL FS, reinjection of untreated groundwater was previously approved by the regulatory agencies for the HD field pilot tests conducted in 2004 and 2005. Under HD, groundwater injection and extraction are balanced, and reinjection of untreated groundwater carries no additional risk of plume migration. Reinjection of untreated groundwater for purposes of in-situ DNAPL flushing has previously been approved by EPA at other Superfund Sites, such as the UPRR Tie Plant Site in Laramie, Wyoming. At the UPRR Laramie Site, untreated groundwater was reinjected and facilitated the recovery of more than 1.8 million gallons of wood treating oils from the alluvial aquifer.

Montrose believes that HD with untreated groundwater reinjection should be retained as a candidate alternative. However, Montrose is also amenable to retaining HD with treated groundwater injection through to detailed analysis.

### **EPA Comment**

*Unit Cost of HD and Steam Injection: In Specific Comment No. 155, EPA indicated that..."The unit NPV cost will range from about \$108 to \$173 per lbs of MCB removed for Alternative 5a, and will be significantly higher (about \$365 per lbs of MCB removed) for Alternative 4."*

### **Montrose Response**

The unit costs calculated by EPA are incorrect. EPA has calculated unit costs by dividing the entire RA cost by the mass removal estimated for HD or steam injection. However, the entire RA costs include other remedy components such as containment, institutional controls, and SVE in the unsaturated zone, and the mass removed by SVE is not accounted for in EPA's calculation. To evaluate the true cost



effectiveness, the cost of the HD or steam injection remedial component must be divided by its associated estimated mass removal. Accordingly, using EPA's estimates of MCB mass removal, the correct unit costs for HD and steam injection are as follows:

- RA 4 or HD = \$182 per pound of MCB removed (or \$91 per pound of DNAPL removed)
- RA 5A or Steam Injection = \$93 to \$149 per pound of MCB removed which is the same cost per pound of DNAPL since DDT is not removed by steam injection

Additionally, the cost of RA 5A is dependent on the number of soil pore volumes flushed with steam. The costs presented in the DNAPL FS were based on an average of 2.5 pore volumes of steam flushing. However, as indicated in these responses, Montrose does not agree with that assumption. Given the geologic setting and DNAPL architecture, between 3 and 6 pore volumes of steam flushing or more is an appropriate assumption for the Site, and a comparison of DNAPL remedy unit costs are presented below for two different pore volume flushing assumptions.

<b>DNAPL Mass Estimate</b>	<b>RA 4 Hydraulic Displacement (50-foot well spacing)</b>	<b>RA 5A Focused Steam Injection (2.5 Pore Volumes)</b>	<b>RA 5A Focused Steam Injection (6 Pore Volumes)</b>
DNAPL FS	\$33/lb DNAPL \$66/lb MCB	\$113/lb MCB	\$157/lb MCB
EPA Mass Estimates	\$91/lb DNAPL \$182/lb MCB	\$93 - \$149/lb MCB	\$130 - \$207/lb MCB
Partially Corrected EPA Mass Estimates	\$51/lb DNAPL \$102/lb MCB	\$75 - \$119/lb MCB	\$104 - \$166/lb MCB

Notes:

lb = pound

Unit costs reflect net present value of candidate DNAPL RA.

Using the DNAPL FS or partially corrected EPA mass estimates and assuming 80% recovery of mobile DNAPL mass, DNAPL remedy unit costs for HD are lower than unit costs for steam injection over a focused treatment area. HD remedy unit costs would be even lower if more than 80% of the mobile DNAPL mass were recovered, such as demonstrated at the UPRR Laramie Site. Although site conditions are dissimilar to the Montrose Site, up to 94% of the mobile DNAPL mass was recovered during HD pilot testing at the UPRR Laramie Site (EPA/625/R-94/003, September 1994) and up to 95% of the mobile DNAPL mass was recovered during full-scale HD operations (Sale and Applegate, 1994). If 95% of the mobile DNAPL mass were recovered at the Montrose Site, the HD remedy unit costs would be \$28 per pound of DNAPL or \$56 per pound of MCB using the DNAPL FS mass estimates.

Remedy unit costs for steam injection over the entire DNAPL-impacted area (RA 5B) are even higher. EPA estimated that between 10,000 and 32,000 pounds of MCB could be recovered by steam injection outside of the focused treatment area (i.e., if full-scale steam injection were implemented). Although not presented in the DNAPL FS, Montrose has previously estimated the incremental cost of a full-scale steam injection remedy at \$35 to \$60 million NPV assuming 3 to 6 pore volumes of steam flushing (incremental to cost of steam injection over a focused treatment area). Therefore, the incremental unit cost to remove the additional MCB outside of the focused treatment area is \$1,000 to \$6,000 per pound of MCB.

Although the corrected unit costs are provided in this response, Montrose does not agree with EPA's estimates of DNAPL mass or mass removal as indicated in these responses. Additionally, Montrose does

not agree that liquid-phase DDT removed by HD should be excluded from the cost comparison. DDT is a component of DNAPL, a hazardous substance, and a reduction in hazardous substance toxicity and volume is recognized by the National Contingency Plan (NCP). The ability of candidate RAs to reduce the toxicity and volume of hazardous substances should be considered in the DNAPL FS.

## Comments Related to Steam Injection (RA 5A and 5B)

### EPA Comment

*Post-Thermal Residual MCB Saturations of 4% and 0.5%: In Specific Comment No. 32, EPA indicated that..."For example, the bench top steam test resulted in a reduction of MCB concentration to the equivalent of 4 percent of the pore space (saturation of 0.04). Figure 1 shows the predicted MCB soil concentration profile for borehole PSB-4 if MCB saturations are reduced to 0.04 and 0.005 from thermal technology." The basis for the 0.5% residual saturation and the calculation of residual saturations were subsequently provided by EPA in a letter dated March 11, 2010.*

### Montrose Response

**4% Residual MCB Saturation:** EPA's basis for the 4% residual MCB saturation is the post-test results from Run 1 of the 2-D bench scale steam injection study, where a maximum MCB concentration of 14,000 mg/kg was detected in the test cell following treatment (i.e., 14,000 mg/kg MCB is equivalent to 4% saturation on a dry weight basis). Using a maximum residual MCB concentration from the 2-D experiments would be appropriate for estimating a minimum MCB mass removal range for steam injection. However, a higher post-test MCB concentration of 20,000 mg/kg was detected in Run 2 post-test soils, which is roughly equivalent to a 6% residual MCB saturation.

In Specific Comment No. 131, EPA estimates MCB mass removal by steam injection assuming a 4% residual saturation as follows:

- RA 5A, Focused Treatment Area = 144,000 pounds of MCB removal
- RA 5B, Entire DNAPL-Impacted Area = 143,000 pounds of MCB removal

In spite of treating a significantly larger area (160,000 versus 26,000 square feet), EPA estimates less MCB mass removal for full-scale steam injection (RA 5B) than for focused steam injection (RA 5A), which is clearly an error. The mass estimate calculations provided in the letter dated March 11, 2010, showed approximately 46,103 pounds of MCB outside of the focused treatment area prior to steam injection but 46,774 pounds of MCB over the same area following steam injection.

Outside the focused treatment area, there are only three soil borings with MCB saturations greater than 4% (DP-7, SSB-2, and TSB-2). Using EPA's methodology and reducing the MCB saturation at these three borings to 4%, an estimated 10,500 pounds of MCB would be removed by implementing steam injection outside of the focused treatment area (dry weight basis). EPA should have estimated 154,500 pounds of MCB removal for steam injection over the entire DNAPL-impacted area (RA 5B) on a dry weight basis.

**0.5% Residual MCB Saturation:** In a letter dated March 11, 2010, EPA indicated that the basis for the 0.5% was a post-field pilot test result from the Unocal Site in Guadalupe, California as follows:

*"The 0.5 percent saturation is a value that was achieved at the Guadalupe Refinery steam pilot test within 15 feet of the steam injection wells. The nonaqueous phase liquid (NAPL) at that site was a diluents hydrocarbon admixture with a boiling point higher than that of the DNAPL at Montrose, so the 0.5 percent was taken to be a reasonable low end-member in the spectrum of possibilities."*

Montrose does not agree with using the steam injection field pilot test results from the Guadalupe Refinery to estimate a maximum range of effectiveness for the Montrose Site. Conditions associated with

the Guadalupe Refinery are significantly different from the Montrose Site, and therefore, field pilot test results do not reasonably approximate the performance of steam injection at the Montrose Site. Specific differences which would result in an overestimation of mass removal for the Montrose Site are as follows:

- Geology: The lithology of the steam injection pilot test at the Guadalupe Site is a thick, homogenous sand. This soil type is ideally suited for steam injection and will result in an overestimation of MCB mass removal as compared to the heterogeneous and layered lithology of the UBA at the Montrose Site.
- Contaminant Type: The contaminant at the Guadalupe Site is a long-chain hydrocarbon identified as having components from C<sub>12</sub> to C<sub>30</sub>. The contaminant will react differently to thermal remediation than the chlorinated benzene ring at the Montrose Site, a C<sub>6</sub> compound. The lighter ends of the long-chain hydrocarbons were partially volatilized while the heavier components were flushed for recovery as a liquid-phase NAPL. The majority of the NAPL removal during the Guadalupe Refinery pilot test was from multiphase extraction wells located outside the thermal treatment area. The contaminant type at the Guadalupe Site is fundamentally different and does not reasonably simulate the DNAPL at the Montrose Site.
- Post-Test Contaminant Concentration: EPA has selected a saturation level based on a soil sample located 15 feet from a steam injection well at the Guadalupe Site, although the sample was not identified. Based on a report entitled *Pilot Test Panel Report on the Hot Water/Steam Injection Pilot Test for the Former Guadalupe Oil Field* (Pilot Test Panel, August 2005), soil was sampled following the pilot test at ten different locations identified as POS1 through POS10 and ranging from 15 to 43 feet from a steam injection well. There was only one post-test sampling location, POS9, which was 15 feet from a steam injection well. The report indicates the following:
  - Multiple soil samples were collected at various depths at this boring;
  - Residual contaminant concentrations up to 7,000 mg/kg were detected in this boring; the average residual contaminant concentration at POS9 was approximately 3,300 mg/kg or 1.6% residual saturation;
  - Location POS9 received an estimated 21.6 pore volumes of steam flushing;
  - The contaminant mass at POS9 was reduced by 85%, which was the highest removal efficiency observed in the ten post-test sampling locations (average of 56% mass removal for all ten locations).

For the Montrose Site, EPA has proposed a spacing of 60 feet between injection/extraction wells. Use of a post-test result located only 15 feet from an injection well will overestimate the effectiveness of steam injection at the Montrose Site. EPA has additionally proposed only 2 to 3 pore volumes of steam flushing for the Montrose Site. Use of a post-test result which received an estimated 21.6 pore volumes of steam flushing will significantly overestimate the effectiveness of steam injection for the Montrose Site.

Montrose notes that an average post-test residual contaminant saturation of 0.5% was not achieved by the steam pilot test at the Guadalupe Site. After evaluating the performance of the steam pilot test at the site, the Pilot Test Panel estimated the performance of a theoretical steam injection remedy under optimized conditions including an injection well spacing of only 20 feet. Under optimal conditions, the Panel estimated that contaminant concentrations could be reduced to between 1,000 and 5,000 mg/kg or 0.5% to 2.5% residual saturation. Therefore, EPA has based the maximum range of steam injection effectiveness at the Montrose Site on the estimated performance of a hypothetical steam injection system under optimized conditions, which do not reasonably simulate the conceptual design for the Montrose Site. Montrose does not agree with use of a hypothetical performance standard from a site with significantly

different conditions and assumptions for well spacing and pore volumes of steam flushing. Montrose notes that steam injection was not implemented full-scale at the Guadalupe Site because the cost of the optimized system was determined to be prohibitive (i.e., in excess of \$300 million).

Alternate Mass Removal Assumption: Alternately, in lieu of using an assumed 0.5% to 4% residual saturation, the actual MCB mass removal from the 2-D study results could be used as a basis for evaluating steam injection. Between 34 and 38 post-test soil samples were collected from the DNAPL-impacted layer in each experiment run and analyzed for the presence of MCB. These detailed post-test sampling results were used to estimate the amount of MCB mass removal for each run at between 57% and 64% for the two experiment runs. The 2-D bench-scale studies provided MCB mass removal efficiencies for steam injection under simulated conditions, which are more reliable than the hypothetical performance of a steam injection system at a site with dissimilar contaminant and geologic conditions.

### **EPA Comment**

*Effectiveness Ranking for Steam Injection:* In Specific Comment No. 77, EPA indicated that... "The statement that this alternative "may" be effective in reducing DNAPL residual mass and mobility is incorrect. Given the physical testing and comparative evaluation of DNAPL physical properties, it should be stated that thermal treatment of MCB in the DNAPL would be highly effective at the site."

In General Comment No. 1, EPA indicated that... "On the other hand, both steam injection alternatives were ranked "potentially effective" (the lowest rank after "ineffective"), although these alternatives are likely to meet all RAOs."

### **Montrose Response**

The effectiveness of steam injection to remediate DNAPL-phase MCB at the Montrose Site is uncertain. The layered and low permeability nature of the UBA is not ideal for steam injection and will pose significant challenges for a steam remedy. For HD alternatives, EPA has questioned the continuity of the UBA soil layers and indicated a potential for downward migration through discontinuities. These lithologic conditions would also reduce the effectiveness of steam injection. Of significance is that a DNAPL bank will form at the steam front. DNAPL saturations and capillary pressures will increase with travel distance, resulting in an increased risk of vertical mobilization with time and distance during application of a steam remedy. HD will not result in the same degree of saturation and capillary pressure increase since residual DNAPL will be left in place.

While the sand layers may have adequate permeability to support steam injection, the silt layers will not. An increased amount of steam flushing may be required to heat the low permeability layers by conductive heating, and since steam injection is dependent on permeability, there is significant uncertainty regarding the potential effectiveness of steam injection to heat the low permeability layers. Furthermore, the sand layers may not be continuous over the treatment area. Sand lenses which pinch out may not be effectively heated or steam flushed if not in hydraulic communication with a multiphase extraction well. Even in thicker sand layers, preferential flow within the layer may result in the steam overriding the DNAPL accumulated at the bottom of the layer.

Given the uncertainties associated with the effectiveness of steam injection at the Montrose Site, the most appropriate ranking would be "potentially effective". If the DNAPL architecture were different, such as a DNAPL located within a high permeability sand overlying a thick, low permeability, and continuous capillary barrier, then a higher effectiveness ranking may be appropriate. However, given all the uncertainties associated with application of steam injection to the Site, a "highly effective" ranking is not justified.

Remediation of DNAPL in a heterogeneous, low permeability aquitard is challenging, and it is unlikely that any candidate remedial technology will be ranked as “highly effective”. Steam injection is not a presumptive remedy for the Montrose Site. A “highly effective” ranking cannot be arbitrarily assigned to this technology.

There is no technical basis for an effectiveness ranking of “highly effective”. In Specific Comment No. 131, EPA indicates a low range for MCB mass removal by steam injection of 49% for a full-scale application, which does not justify a “highly effective” ranking for steam injection. The potential effectiveness of steam injection under two specific scenarios was evaluated by the 2-D bench scale studies, which demonstrated MCB removal efficiencies of 57% and 64%. These removal efficiencies are relatively low and also do not support a “highly effective” ranking. Although the 2-D studies evaluated scenarios with discontinuous thin capillary barriers, heating approximately two cubic feet of soil in an insulated test cell in the laboratory poses fewer challenges than heating soils at full-scale field conditions. The small treatment volume and reduced heat losses during bench-scale studies can result in an overestimation of steam injection performance relative to full-scale field conditions in spite of the thin and discontinuous capillary barriers used during the two 2-D experiments.

In General Comment No. 1, EPA’s concern appears to be based on the following statement from Sections 4.0 and 5.2 of the DNAPL FS:

*Remedial technologies and process options are evaluated and ranked as effective, moderately effective, minimally effective, potentially effective, or ineffective.*

EPA has interpreted that the term “potentially effective” is ranked above “ineffective” but below “minimally effective”. This interpretation is not correct, and the position of this term in the above statement was not intended to reflect its ranking relative to the other terms. The term “potentially effective” indicates that the effectiveness is uncertain.

### **EPA Comment**

*Conductor Casings for the Hot Floor Wells: In Specific Comment No. 92, EPA indicated that...“Conductor casing is probably unnecessary for the hot floor wells as any DNAPL that might migrate in the Bellflower Sands after completion of these wells would be recovered during steam injection into this interval.”*

### **Montrose Response**

Montrose does not agree that conductor casings are “probably unnecessary” during hot floor well installation. Installation of permanent conductor casings is the most protective method for preventing vertical cross-contamination during drilling. The risk of vertical contaminant migration, either during drilling or behind casing following drilling, is real and has previously occurred at other multi-layer contaminated sites. Given the concerns over vertical migration of DNAPL, Montrose believes that the most protective drilling method should be used to protect the BFS from unnecessary contaminant migration.

EPA’s recommendation to eliminate the conductor casings is surprising and not in accordance with industry standards for protection of second water-bearing zones (i.e., not isolating a DNAPL-impacted zone before drilling ahead to a second water-bearing zone). Although a hot floor within the BFS is included as part of the conceptual design for a steam injection remedy, the hot floor will not universally protect the BFS from chemical impact. For example, steam injected into the upper portion of the BFS would fail to effectively remediate DNAPL accumulating at the bottom of the BFS. If the DNAPL migrated vertically downward during or immediately following drilling, the impact to the BFS would occur prior to the start of hot floor activities. The hot floors wells should be constructed using permanent

conductor casings to isolate the DNAPL in the UBA and minimize the vertical migration risks associated with drilling.

### **EPA Comment**

*Hot Floor Effectiveness: In Specific Comment No. 6, EPA indicated that..."In addition, the effectiveness of a hot floor was confirmed during steam remediation at the Visalia site. This project had a comparable depth and lateral footprint to the focused treatment area footprint at the Montrose property."*

*In Specific Comment No. 8, EPA indicated that..."In addition, injection of steam or an increase in temperature from ERH below the UBA (the "hot floor" for the UBA) would mitigate the adverse impacts associated with the potential vertical mobilization of DNAPL during the thermal remedy."*

*In Specific Comment No. 81, EPA indicated that..."The high permeability and relative uniformity of the Bellflower Sands significantly increases the probability of creating a "hot floor" under the UBA has several advantages: 1) it will increase the uniformity of heating within the UBA as the steam and heat will rise into the UBA, just as steam injected into the lower aquitard at Visalia aided in heating and treating the intermediate aquitard; 2) it will mitigate any potential migration of MCB DNAPL into the Bellflower Sands, further increasing the overall effectiveness."*

### **Montrose Response**

The DNAPL-impacted area at the Montrose Site is approximately 160,000 square feet or 3.7 acres. A hot floor of this size has never previously been implemented, anywhere. It is difficult to over-emphasize the limitations of a technique that has never previously been implemented at this scale.

On behalf of EPA, CH2M Hill conducted an evaluation of 177 thermal remediation sites. Montrose conducted a similar evaluation of 119 thermal case sites. In all those sites, a hot floor was only implemented seven times, including six ERH case sites and one steam injection case site (the SCE Visalia Site). None of the ERH hot floors were conducted in a sand aquifer underlying a DNAPL-impacted UBA, and two of the six ERH hot floors failed to reach target temperature. The SCE Visalia Site was the only site with heating of an aquifer unit underlying a DNAPL impacted aquitard. However, the Visalia Site was not a true hot floor since heating of the underlying aquifer unit was conducted to prevent the upward flow of cool groundwater into the thermal treatment zone, and there was minimal risk of downward migration since the heated NAPL (creosote) had a density near or slightly less than that of water, i.e., behaving more like a LNAPL. Additionally, only a portion of the underlying aquifer at the Visalia Site was heated using three steam injection wells compared to an estimated 55 steam injection wells required for the hot floor under RA 5B at the Montrose Site. Therefore, less than 4% of the thermal case sites implemented a hot floor in any manner, and none of the thermal case sites implemented a hot floor in a manner similar to the Montrose Site. There is no basis of experience upon which to reliably evaluate the potential effectiveness of a hot floor at the Montrose Site.

The BFS is a permeable sand aquifer, and steam could be injected into that aquifer in an effort to prevent and/or treat DNAPL migrating vertically downward from the UBA. However, there is insufficient data from other sites upon which to reliably say that the hot floor will be effective in preventing and/or treating DNAPL that migrates vertically downward. It is not uncommon for even permeable sands to exhibit some type of anisotropy, which could result in preferential steam flow. Additionally, there is the potential for cooling of the hot floor along the perimeter. The possibility also exists that cold spots could develop in the hot floor, and that the effectiveness of the hot floor at those cold spots would be at least partially impaired. There is clearly a real risk that some DNAPL could migrate vertically downward even with a hot floor. Hot floors are infrequently implemented and never under conditions or a scale similar to the Montrose Site, and therefore, EPA overestimates the potential effectiveness of a hot floor.

### **EPA Comment**

*Fugitive Emissions: In General Comment No. 6, EPA indicates that..."Therefore, the PD will likely serve as an effective cap for any vapor that may potentially migrate laterally during thermal treatment...Based on the above, it is highly unlikely that the site related contaminants from the saturated zone could pass the vadose zone without being captured."*

*In Specific Comment No. 11, EPA indicates that..."The text mentions fugitive emissions that were experienced at Silresim and Visalia projects. Thermal remediation technology has improved significantly since these were implemented, and there is much to be learned from prior project in optimizing the design, construction and operation of a thermal treatment system. At Visalia the geyser resulted from an attempt to preserve a monitoring well just outside of the treatment area, but it was not constructed for high temperatures, and the bentonite around the well was washed out." This happened late in the project, when there was a lot of energy still in the subsurface, but not much creosote remaining. Although grit and water were sprayed into the air, there were no contaminants released. At Silresim, there was a small release due to failure of a wellhead, but an alternative suitable material was found to re-build the wellhead. In neither case was there a fatal flaw in the design that impacted the outcome."*

### **Montrose Response**

The risk of fugitive emissions during thermal remediation has been underestimated by EPA. Over 200 soil borings and soil gas probes have been drilled at the Site since 1985. Previously abandoned borings may offer a migration pathway for steam and/or heated vapors following heating. Bentonite or bentonite-rich cements are subject to shrinking, significant shrinking in some cases, when heated. There is no way to guarantee that these previously abandoned borings will not create a fugitive emission during thermal remediation. It has happened at other sites (e.g., SCE Visalia Site), and it could happen at the Montrose Site as well. Re-abandonment of borings using a temperature-resistant cement would reduce the risk of fugitive emissions. However, many of these borings are more than 20 years old, and it will not be possible to locate all of them and re-abandon with temperature-resistant cement. The former wastewater recycling pond or other buried structures, such as footings and concrete debris, may also offer migration pathways for steam and/or heated vapors to reach surface as a fugitive emission (i.e., thickness of low permeability Playa Deposits reduced at these subsurface features).

Once heated, the subsurface will remain hot for some time and can continue to generate steam and/or heated vapors in-situ. Interruptions in the vapor recovery system, if excessively long, have an increased potential of creating a fugitive emission. A full-scale thermal remedy would involve 116 steam injection and 75 multiphase extraction wells, including the hot floor. The number of pipe joints, flanges, or other type of connections associated with a thermal remedy and subject to potential fugitive emissions could easily exceed 1,000 connections. Over time, the integrity of the numerous fittings, gaskets, and seals could become compromised by thermal remediation operations. In spite of the experiences and lessons learned at prior thermal remediation sites, prevention of fugitive emissions remains a genuine concern for implementation of thermal remediation projects today especially under the scale and conditions at the Montrose Site.

### **EPA Comment**

*Del Amo Site References: In General Comment No. 9, EPA indicates that..."There are numerous statements in the FS referencing the Del Amo FS with regard to the use of thermal remedy. The use of thermal treatment at the Del Amo site was considered for treatment of benzene light nonaqueous phase liquid (LNAPL), which typically does not pose the same magnitude of risk as a DNAPL in its potential to contaminate deeper water-bearing zones if left untreated. The dissolved benzene plume also does not migrate laterally and vertically as much as the MCB plume. In addition, there are numerous other considerations at the Del Amo site, such as presence of buildings, that may not apply to the remedy*



*selection at this site. Based on the above, referencing the Del Amo FS with regard to the applicability of thermal treatment is not appropriate.”*

### **Montrose Response**

The applicability of thermal remediation at the Del Amo Superfund Site is relevant to the Montrose Site, which was the basis for including it in the FS. The Del Amo Site is located less than 1,000 feet from the Montrose Site and is literally across the street. Consequently, the lithology of the NAPL-impacted zone is very similar to the Montrose Site and nearly identical within the western portion of the Del Amo Site. Since the complex nature of the UBA poses the greatest challenge to remediation of DNAPL at the Montrose Site, the applicability of thermal remediation at the Del Amo Site is relevant to the Montrose FS.

Although the NAPL at the Del Amo Site is lighter than water (i.e., LNAPL), the NAPL is smeared over a depth interval and thickness comparable to the Montrose Site. Therefore, the target treatment interval at the Del Amo Site (60 to 90 feet bgs) is similar to the Montrose Site (60 to 105 feet bgs).

Montrose recognizes that the Del Amo Site has been redeveloped and agrees that current property use should be considered during the remedy selection process. Although the Montrose Property has not been redeveloped, the former Boeing Property borders Montrose to the north and Jones Chemical, an active chemical plant, borders Montrose to the south. Both properties have the potential to be impacted by a thermal DNAPL remedy where the subsurface can remain hot for years following remedy completion. The proximity of the buildings at the former Boeing Property and Jones Chemical Property should also be considered in the remedy selection process for the Montrose Site.

In the FS for the Del Amo Site, steam injection was not assembled into a formal remedial alternative. The Del Amo FS indicated that “*the low permeability and heterogeneous character of soils at the former plant site would interfere with the uniform transmission of the steam through the subsurface*”. Since the nature of the low permeability aquitard, which is very similar to the Montrose Site, was a primary factor in the decision to not assemble steam injection as a formal remedial alternative, then reference to the Del Amo Site is relevant to the Montrose FS. Therefore, Montrose declines to remove the references as requested by EPA.

### **EPA Comment**

*2-D Bench-Scale Study: In Specific Comment No. 5, EPA indicated that... “Based on our review of the bench scale work plan and results, this test was not adequately designed to address the variability and complexity of geologic and DNAPL distribution conditions at the site. Therefore, the results of this test were not considered to be representative of the performance of the thermal remedy.”*

### **Montrose Response**

Montrose made every effort to simulate site conditions during the 2-D studies and evaluate the performance of a steam remedy. Soil, groundwater, and DNAPL were collected from the site and used in the study. Soils representing three different generalized soil types from the saturated UBA were used to simulate the layered lithology in the test cell. Physical properties testing of the packed soil in the cell were tested to confirm that site conditions had been reasonably duplicated.

Montrose accurately simulated:

- Test pressures consistent with the base of the UBA;
- Differential pressure from steam injection to multiphase extraction point;

- DNAPL occurring within a sand layer and overlying a thin capillary barrier or low permeability silt layer;
- A silty sand basal layer underlying the capillary barrier.

In advance of the studies, Montrose submitted a workplan to EPA in September 2007. EPA commented on the workplan in a letter dated November 8, 2007, and further discussed the 2-D studies with Montrose in meetings on November 14 and 15, 2007. Montrose addressed EPA's comments, prepared an addendum to the workplan, and submitted the Addendum to EPA in February 2008. Montrose met with EPA again on February 26, 2008, and discussed the revisions to the 2-D experiment methodology. EPA had the opportunity to comment on the design of the 2-D study experiments, and Montrose adopted EPA's changes to the scope of work and test setup to the extent possible.

However, there were limitations to the extent that in-situ field conditions could be simulated in a 2-foot tall x 3-foot wide x 4-inch deep laboratory test cell. Some of the capillary barriers at the Site are as much as 4 feet thick. It was physically impossible to simulate a 4-foot thick capillary barrier in a 2-foot tall test cell. Similarly, it was physically impossible to simulate the 10-foot thick basal silty sand layer of the UBA, although the basal layer in the test cell was the thickest layer in the experiment at 25 centimeters or 10 inches. Although size constraint is a limitation of bench-scale testing, bench tests generally do not underestimate the potential effectiveness of thermal remediation in the field where there is much greater geologic complexity and less control over the processes involved in application of the technology. The 2-D steam flushing study involved a simple layering of soils, the test cell was completely confined, there was no groundwater inflow, and the steam injection and extraction wells were in close proximity to the DNAPL pool. Therefore, the bench-scale 2-D steam flushing study would not have seriously underestimated the performance of a thermal remedy in the field, particularly with respect to recovery of MCB and DDT. Given the limited variability and complexity of the 2-D experiments, the bench-scale study likely overestimated the performance of a field-scale thermal remedy.

Although EPA indicates in Specific Comment No. 5 that "*the results of this test were not considered to be representative of the performance of the thermal remedy*", Montrose notes that EPA has used the results of Run 1 from the 2-D studies to estimate a range for MCB mass removal during steam injection as indicated in Specific Comment No. 32.

### **EPA Comment**

*References to the 2006 Basel paper for Koppers Site: In Specific Comment No. 80, EPA indicated that... "The relevance of text cited by Basel, (2006) is questionable. Preparation of this paper appears to have been for Koppers, a known and vocal opponent of in-situ thermal treatment for DNAPL remediation. Please remove reference to this document as it is not an objective source of information."*

### **Montrose Response**

Montrose believes that reference to this site and technical author are appropriate, relevant, and declines to remove the reference from the DNAPL FS. Dr. Michael Basel is a respected technical expert in the environmental community. Dr. Basel is Vice President of Remedial Technology Development with Haley & Aldrich. He received a doctorate in Mechanical Engineering from the University of California at Berkeley, and his doctoral thesis was entitled *Two-Dimensional Propagation of Steam through Partially Saturated Porous Media*. Dr. Basel has participated in numerous thermal remediation projects including the Unocal steam injection pilot test in Guadalupe, California. Dr. Basel is a member of the Thermal Technical Advisory Committee for the Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP). Dr. Basel participated in an expert panel workshop on *Reducing the Uncertainty of DNAPL Source Zone Remediation* (SERDP/ESTCP, September 2006). In May 2008, at a California DTSC Remediation

Symposium (co-sponsored by EPA Region 9), Dr. Basel was invited to speak and presented the evolution of thermal technologies for remediation. Dr. Basel was recently selected by the State of Washington to participate in an expert panel review of the Wyckoff Harbor Superfund Site in Region 10. Dr. Basel is a recognized expert in the field of thermal remediation technologies, and his evaluation of the applicability of thermal remediation at the Cabot Carbon/Koppers Superfund Site in Gainesville, Florida should not be dismissed.

The reference shown on Page 5-38 of the DNAPL FS is from Section 2.3.3 of Dr. Basel's paper and discusses the Technology Challenges associated with in-situ steam injection. Dr. Basel indicates that "*steam injection is most effective in formations with hydraulic conductivities of  $10^{-3}$  cm/sec or greater*". Although this statement is general in nature, it is applicable and relevant to both the Cabot Carbon/Koppers and Montrose Superfund Sites. At both sites, steam injection was considered as a remedial alternative for DNAPL impacts to a low permeability aquitard zone. At the Cabot Carbon/Koppers Site, the Hawthorn Group was identified as "interbedded and intermixed clays, silty-clayey sand, sandy clay, and occasional carbonate beds". Dr. Basel reported the clay layers as having a hydraulic conductivity of  $10^{-6}$  to  $10^{-7}$  cm/sec. The hydraulic conductivity of the silt layers within the UBA at the Montrose Site has been measured at  $2.4^{-5}$  to  $1.4^{-6}$  cm/sec. Therefore, Dr. Basel's comment regarding the applicability of steam injection to low permeability aquitards at the Cabot Carbon/Koppers Site is relevant to the evaluation of this technology at the Montrose Site.

#### **EPA Comment**

*TerraTherm's Conductive Heating Technology: In Specific Comment No. 53, EPA indicated that... "Unless TerraTherm has specifically indicated its thermal conduction technology is incompatible with DDT due to its potential for thermal decomposition and acid gas formation, please remove "such as DDT" from the last sentence of this paragraph."*

#### **Montrose Response**

AECOM consulted with TerraTherm during preparation of the FS, and conclusions regarding the applicability of the ISTD thermal technology to the Site are based on recommendations made by TerraTherm in 2007. The Montrose DNAPL is heavily chlorinated, and application of ISTD to the Site would be expected to generate a significant quantity of acid gas. The Montrose DNAPL is composed of DDT (5 chlorine atoms per molecule) and MCB (1 chlorine atom per molecule). DDT is reported to decompose and/or boil at temperatures between approximately 185°C and 260°C, and ISTD heats soils conductively at temperatures up to approximately 650°C (at heater wells). As a result, a portion of the DDT would be decomposed and/or boiled during conductive heating, resulting in the generation of significant acid gas. Excessive acid gas production during ISTD implementation has been shown to corrode metal well casings, heater elements, wellhead controls, and aboveground piping.

In March 2002, TerraTherm implemented ISTD at a chlorinated pesticide site in Colorado, the Rocky Mountain Arsenal (RMA) site. The chlorinated pesticide at the RMA site, hexachlorocyclopentadiene (also called Hex), contained 6 chlorine atoms per molecule with a boiling point of approximately 239°C, similar to the DDT at the Montrose Site. ISTD remediation of the RMA site was terminated after only 14 days due to excessive acid gas production and severe metallurgical damage to the remediation system components. In a report entitled *Field Evaluation of TerraTherm In Situ Thermal Destruction (ISTD) Treatment of Hexachlorocyclopentadiene* (EPA, July 2004), EPA reported that "*components of the ISTD system at the Hex Pit failed due to severe and rapid corrosive attack*". The Remediation Venture Office conducted an evaluation of the system failure (Appendix B of aforementioned document) and concluded that "*the primary causes of failure of this system were due to an underestimation of volume of HCl*

*generation during remediation, an inappropriate equipment material choice for the site conditions, and an overestimation of buffering capacity of surrounding soils”.*

Although TerraTherm has improved the corrosion resistance of their system design in recent years, in-situ generation of acid and acid gases remain a significant challenge for implementation of ISTD at sites with highly chlorinated pesticides. Montrose proposes to revise the statement in Section 4.6.2 to say that:

“ISTD is not readily applicable to soils impacted with highly chlorinated pesticides due to in-situ formation of acids and acid gases which can result in severe corrosion of metal well casings and other remediation components”.

#### **EPA Comment**

*Staged Thermal Implementation: In General Comment No. 11, EPA indicated that...”One option is to implement the full scale remedy in consecutive parcels or phases. This is precisely the approach taken at the Port of Ridgefield in Vancouver, Washington, and at the ATOFINA bulk terminal in North Carolina, where in-situ thermal treatment by steam and ERH, respectively, were implemented in phases. The use of the phased approach to treating the entire DNAPL area in consecutive treatment cells would be comparable to the focused area treatment alternative with regard to implementability. This approach allows for the re-use of treatment equipment and, more importantly, allows lessons learned in the operation of the treatment system to be incorporated into subsequent implementation efforts. The phased approach for the entire treatment area could also provide the additional benefit of serving as a “pilot test” for the technology at the site. Phasing full-scale steam treatment eliminates many of the implementation concerns cited in the screening of this alternative. Infrastructure requirements, water treatment, and re-injection flows would all be comparable to that of Alternative 5a, which was retained for detailed analysis.”*

#### **Montrose Response**

While there are some advantages to a staged thermal remediation, this approach does not significantly reduce the implementability challenges of a large and complex full-scale steam injection project. No matter how many stages are considered, the treatment volume for full-scale steam injection does not change. In essence, one set of implementability challenges are exchanged for a second and different set. Instead of facing the challenge of treating all 160,000 square feet in one stage, multiple stages would be required (up to approximately 5 stages based on the focused treatment area size). Challenges associated with a multi-stage thermal remediation project include (a) increased potential for lateral contaminant migration outside of the treatment area, (b) multiple construction events, and (c) increased project duration. Multi-staged thermal remediation projects result in a greater amount of the treatment volume occurring along the perimeter of a thermal treatment area at one stage or another. In turn, this results in a greater potential for perimeter effects such as cooling or lateral migration.

Additionally, a staged thermal remedy does not result in significant cost savings. Any cost savings generated by re-use of aboveground equipment from a prior stage are offset by new costs incurred during multiple construction events and an extended project duration. The primary factor affecting thermal remediation costs is the treatment volume, and the overall treatment volume is not reduced by a multi-stage implementation approach. Implementability challenges associated with a large-scale and complex steam injection remedy cannot be avoided simply by conducting the remedy in stages.

## **Other Comments**

### **EPA Comment**

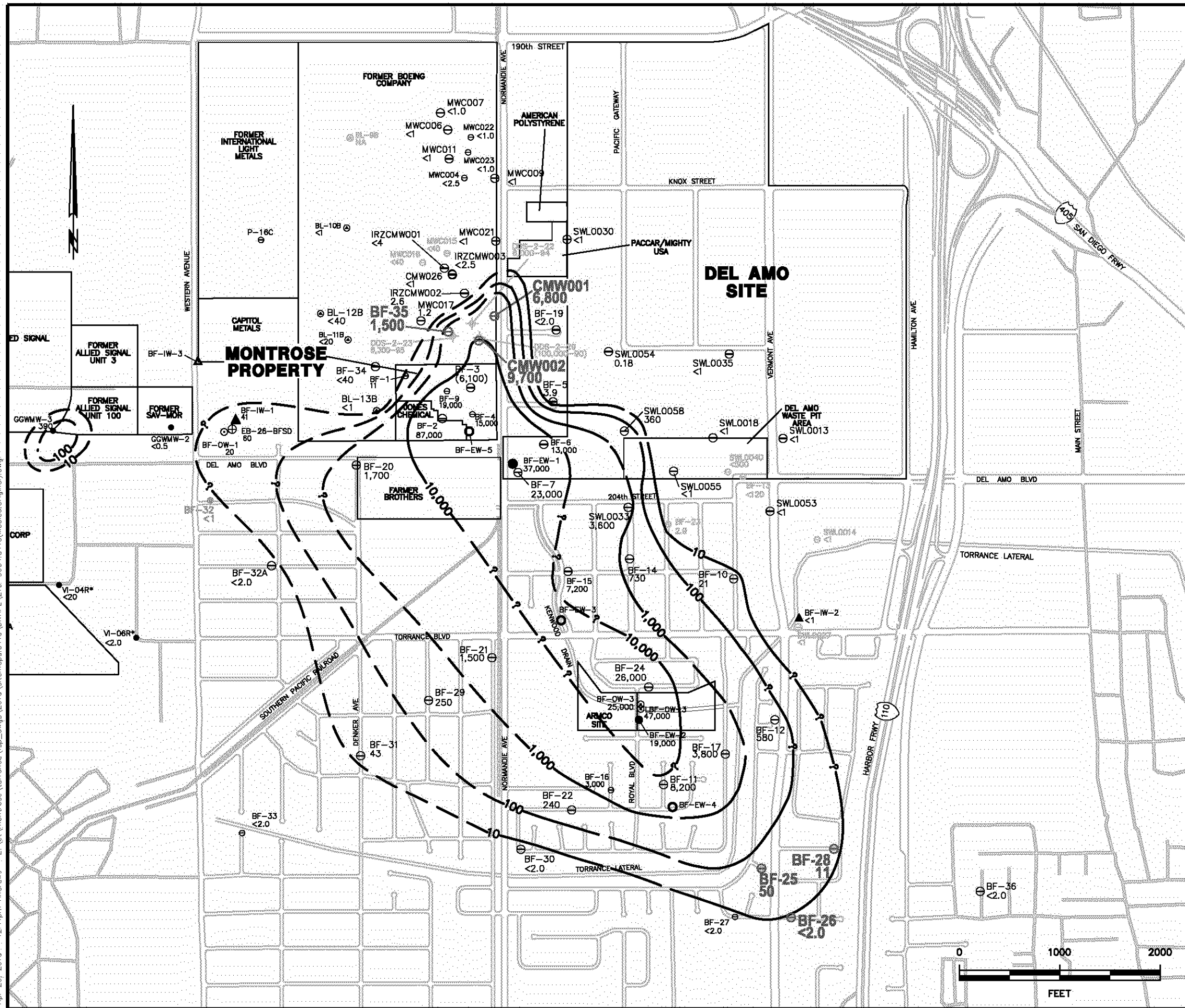
*Vadose Zone Soils Between 10 and 25 feet bgs: In Specific Comment No. 24, EPA indicated that... "Soil in the deeper portion of the PD (between 10 feet and approximately 25 to 30 feet bgs) is not addressed in the DNAPL FS and is not currently planned to be addressed by the Soil FS. A remedial strategy addressing the depth interval between 10 feet and 25 to 30 feet bgs should be developed in either the Soils FS or the DNAPL FS, and decision documented in the ROD for one of these Operable Units."*

### **Montrose Response**

Vadose zone soils between approximately 4 and 25 feet bgs are identified as the Playa Deposits and are composed of predominantly fine-grained, low permeability soils. Physical properties testing of representative soil samples has demonstrated that these soils contain approximately 83% silt and clay and exhibit a horizontal permeability to air of only 0.002 Darcies as indicated in the *Revised Soil Vapor Extraction Pilot Test Report* (Earth Tech, June 2009). Testing of these low permeability soils in 2003 demonstrated that soil vapor extraction (SVE) would be marginally effective to ineffective in removing VOCs. An elevated vacuum of 16 inches of mercury was required to induce soil vapor flow in the pilot test well, following which significant vertical communication with the underlying and higher permeability Palos Verdes Sand was observed. Based on the characterization data and pilot testing results, SVE was not identified as a remedial strategy for the low permeability soils between 10 and 25 feet bgs.

Instead, the remedial strategy for the soils between 10 and 25 feet bgs is the same as for the soils between 4 and 10 feet bgs. That remedial strategy would be to manage VOCs in shallow soil gas using a surficial cap (i.e., vapor barrier) and vapor control system. The barrier system would protect human health and the environment by preventing exposure to VOCs in shallow soil gas. The surficial cap and vapor control system is addressed in the Soil FS and was not reiterated in the DNAPL FS. Montrose recommends that the remedial strategy for soils between 10 and 25 feet bgs be added to the Soil FS, and the remedial decision documented in the ROD for the Soils Operable Unit.

Apr 26, 2010 12:11pm AndrewJ - Z:\montrose\torrance\figs\dwgs\2010\site\maps\0410\DNAPL\210-3604\0410(Modified).Original.dwg



## EXPLANATION

- CMW002**  
9,700  
BF-28  
58  
BF-13  
<120  
BF-EW-2  
BF-IW-1  
BF-EW-3  
BF-IW-3  
BF-OW-3  
DDS-2-22  
6,000-84  
BL-10B  
EB-26-BFSD  
BF-32  
NA  
(100,000)
- BELLFLOWER SAND MONITOR WELL AT PLUME TOE AND NORTH OF MONTROSE PROPERTY  
CONCENTRATION IN MICROGRAMS PER LITER  
BELLFLOWER SAND MONITOR WELL  
CONCENTRATION IN MICROGRAMS PER LITER, SAMPLED BETWEEN 2004 AND 2009  
BELLFLOWER SAND MONITOR WELL  
CONCENTRATION IN MICROGRAMS PER LITER, SAMPLED PRIOR TO 2004  
BELLFLOWER SAND EXTRACTION WELL  
BELLFLOWER SAND INJECTION WELL  
PROPOSED BELLFLOWER SAND EXTRACTION WELL  
PROPOSED BELLFLOWER SAND INJECTION WELL  
BELLFLOWER SAND OBSERVATION WELL  
BOEING HYDROPUNCH SAMPLE LOCATION  
CONCENTRATION IN MICROGRAMS PER LITER  
SAMPLE COLLECTION DEPTH AND YEAR COLLECTED. CLUSTER WELL  
EXPLORATORY BORING AND TEMPORARY BELLFLOWER SAND MONITORING WELL  
DESTROYED MONITOR WELL  
NOT ANALYZED  
CONCENTRATION NOT CONTOURED

? — 100 — ?  
CONTOUR LINE OF EQUAL CONCENTRATION OF CHLOROBENZENE IN MICROGRAMS PER LITER DASHED WHERE APPROXIMATE, QUERIED WHERE INFERRED; BASED ON MOST RECENT SAMPLING RESULTS.

\* = WELL SCREENED FROM THE WATER TABLE ZONE INTO THE MIDDLE BELLFLOWER "C" SAND.

< = LESS THAN; NUMERICAL VALUE IS THE LIMIT OF DETECTION FOR THIS ANALYSIS.

### WELL IDENTIFIER NOTES:

- BF = MONTROSE MONITOR WELLS  
SWL = DEL AMO MONITOR WELLS  
WCC, MWC, CMW = BOEING MONITOR WELLS  
IRZCMW = BOEING BIOREMEDIATION WELLS  
BL = INDUSTRIAL LIGHT METAL MONITOR WELLS

NOTE: IN THE AREA WEST OF WESTERN AVENUE NOT ALL HISTORICAL DATA ARE SHOWN. DETAILS ARE PROVIDED IN: H+A TECHNICAL MEMORANDUM RESULTS OF WEST OF WESTERN AVENUE GROUNDWATER ASSESSMENT MONTROSE SITE TORRANCE, CALIFORNIA, APRIL 24, 2009

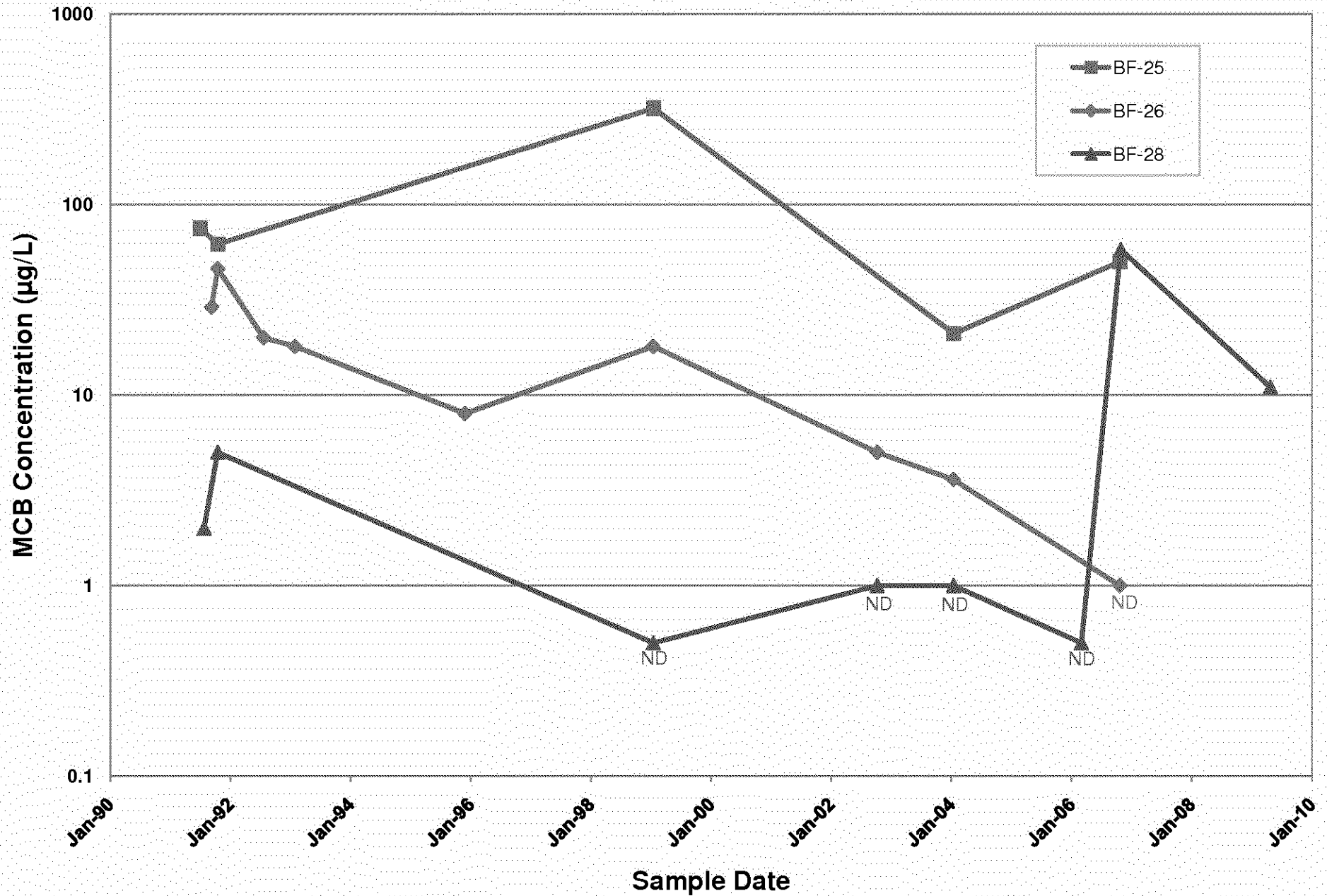
MONTROSE CHEMICAL CORPORATION  
OF CALIFORNIA  
TORRANCE, CALIFORNIA

## FIGURE 1 CHLOROBENZENE BELLFLOWER SAND, APRIL 2009

HARGIS + ASSOCIATES, INC. 04/10  
Hydrogeology/Engineering

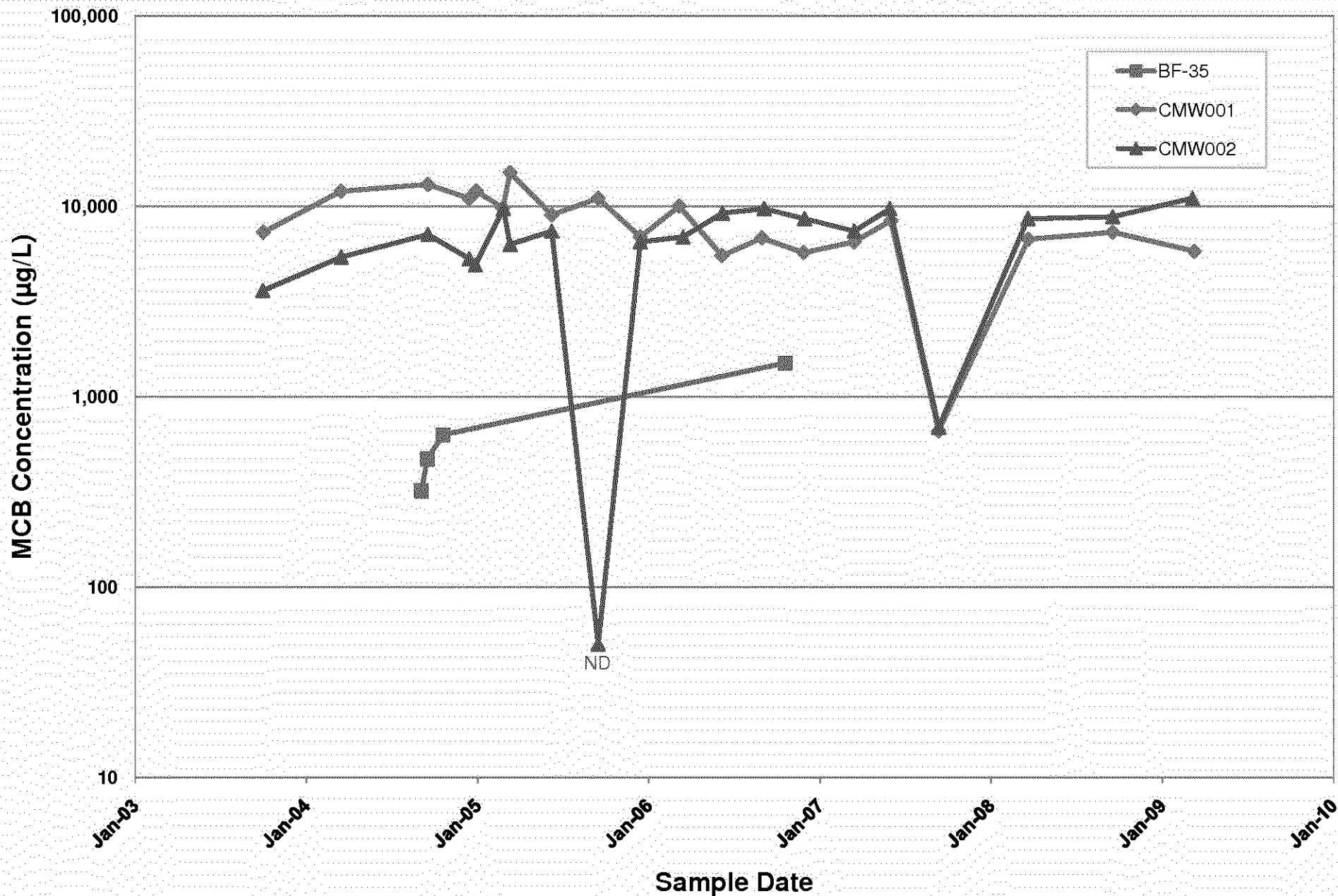
PREP BY GLW REV BY DMO RPT NO. 857.50C 210-3604 B

**Figure 2**  
**MCB Concentrations at BFS Plume Toe**  
**Montrose Superfund Site**



ND = Non detect. Concentrations noted as ND are shown as half of the laboratory reporting limit.

**Figure 3**  
**MCB Concentrations North of the Montrose Property in the BFS**  
**Montrose Superfund Site**



ND = Non detect. Concentrations noted as ND are shown as half of the laboratory reporting limit.



**Figure 4**  
**Montrose Superfund Site MCB Mass**  
**Initial Conditions**

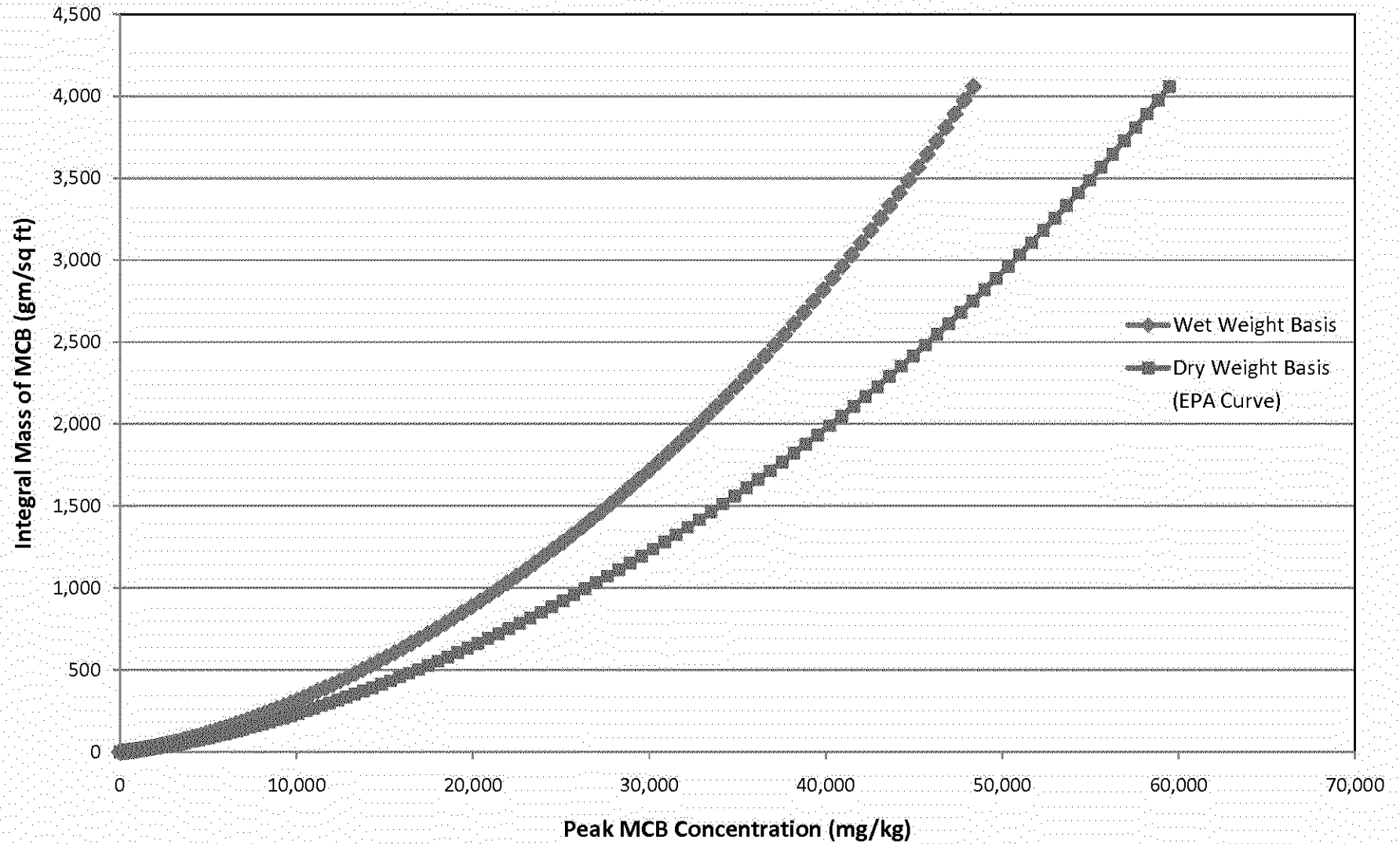


TABLE E-2B  
ESTIMATED DNAPL MASS IN  
UPPER BELLFLOWER AQUITARD  
CALCULATED USING EPA METHOD CORRECTED FOR WET WEIGHT

Boring ID	Peak MCB Concentration in Saturated UBA (mg/kg)	Wet Weight MCB Mass Integral (gm/sq ft)	Contour Area			
			>50,000 mg/kg (gm/sq ft)	>10,000 mg/kg (gm/sq ft)	>1,000 mg/kg (gm/sq ft)	<1,000 mg/kg (gm/sq ft)
DP- 1	480	8.6				8.6
DP- 2	210					
DP- 3	13,000	447.2		447.2		
DP- 4	45					
DP- 5	3,400	72.5			72.5	
DP- 7	16,000	616.1		616.1		
DP- 8	100					
DP- 9	<30					
DP- 10	<30					
DP- 11	<28					
DP- 12	550					
PSB- 1	2,400	48.0			48.0	
PSB- 2	7,100	187.0		187.0		
PSB- 3	3,000	62.3			62.3	
PSB- 4	45,000	3,521.3	3,521.3			
PSB- 5	14,000	500.8	500.8			
PSB- 6	27,000	1,446.6	1,446.6			
PSB- 7	<33					
PSB- 8	<30					
PSB- 9	2,000	38.9			38.9	
PSB- 10	44					
PSB- 11	3,200	67.3		67.3		
PSB- 12	1,400	26.2			26.2	
PSB- 13	<51					
PSB- 14	8,600	244.1		244.1		
PSB- 15	13,000	447.2		447.2		
PSB- 16	49					
PSB- 17	9,300	272.8		272.8		
PSB- 18	5,700	139.2		139.2		
PSB- 19	5,200	123.5		123.5		
SSB- 1	<21					
SSB- 2	23,000	1,106.2		1,106.2		
SSB- 3	<40					
SSB- 4	N/A					
SSB- 5	2,200	43.4			43.4	
SSB- 6	55,000	5,057.8	5,057.8			
SSB- 7	<2,000					
SSB- 8	<40					
SSB- 9	<45					
SSB- 10	<40					
SSB- 11	990	18.1			18.1	
SSB- 12	50,000	4,255.3	4,255.3			
SSB- 13	<40					
SSB- 14	<40					
SSB- 15	<34					
TSB- 1	<50					
TSB- 2	28,000	1,538.6		1,538.6		
TSB- 3	14,000	500.8		500.8		
TSB- 4	<30					
TSB- 5	44					
TSB- 6	<36					
TSB- 7	<34					
TSB- 8	13,000	447.2		447.2		
TSB- 9	47					
TSB- 10	46					
TSB- 11	280					
TSB- 12	<40					
TSB- 13	45					
TSB- 14	40					
TSB- 15	<35					
TSB- 16	<40					
C- 13	<30					
C- 30	8,300	232.2		232.2		
C- 42	<35					
C- 44	4,100	91.3			91.3	
C- 59	66					
S- 101/101A	36,000	2,372.9	2,372.9			
S- 201	N/A					
S- 202	N/A					
S- 203	N/A					
S- 204	N/A					
S- 301/301A	12,000	396.4		396.4		
S- 302A	54	1.3				1.3
S- 302E/302F	N/A					
S- 303/303A	1					
S- 304/304A	4,900	114.4	114.4			
S- 305/305A	81,000	10,336.0	10,336.0			
MW- 2	7,400					
UBT- 1	N/A		10,336.0			
UBT- 2	N/A		10,336.0			
UBT- 3	N/A		10,336.0			
LW- 1	N/A					

Notes:

For purposes of DNAPL mass estimation, recovery wells UBT-1 through UBT-3 were assigned an MCB mass integral value of 10,336.0 gm/sq ft, consistent with the value determined for S-305/305A.

Average (gm/sq ft) =	5,328.5	451.0	50.1	4.9	Subtotal
Area (sq ft) =	30,492	58,141	50,447	23,045	162,125
MCB Mass (lbs) =	357,445	57,694	5,558	250	420,947
DNAPL Mass (lbs)* =	714,890	115,387	11,116	500	841,894
% of Total Mass =	84.9%	13.7%	1.3%	0.1%	100.0%

\*MCB Mass x 2

**TABLE E-3B**  
**ESTIMATED DNAPL MASS IN FOCUSED TREATMENT AREA**  
**SATURATED UPPER BELLFLOWER AQUITARD (60-105 FEET BGS)**  
**CALCULATED USING EPA METHOD CORRECTED FOR WET WEIGHT AND TREATMENT AREA**

<u>Boring ID</u>	Peak MCB Concentration in Saturated UBA (mg/kg)	Wet Weight MCB Mass Integral (gm/sq ft)	Focused Treatment Area MCB Mass Integral (gm/sq ft)
PSB- 4	45,000	3,521.3	3,521.3
PSB- 5	14,000	500.8	500.8
PSB- 6	27,000	1,446.6	1,446.6
SSB- 6	55,000	5,057.8	5,057.8
SSB- 12	50,000	4,255.3	4,255.3
S- 101/101A	36,000	2,372.9	2,372.9
S- 304/304A	4,900	114.4	114.4
S- 305/305A	81,000	10,336.0	10,336.0
UBT- 1	N/A		10,336.0
UBT- 2	N/A		10,336.0
UBT- 3	N/A		10,336.0

Notes:

For purposes of DNAPL mass estimation, recovery wells UBT-1 through UBT-3 were assigned an MCB mass integral value of 10,336.0 gm/sq ft, consistent with the value determined for S-305/305A.

\*MCB Mass x 2

**Average (gm/sq ft) = 5,328.5**

**Area (sq ft) = 26,000**

**MCB Mass (lbs) = 304,787**

**DNAPL Mass (lbs)\* = 609,575**

TABLE E-4B  
ESTIMATED MOBILE DNAPL MASS IN  
UPPER BELLFLOWER AQUITARD  
CALCULATED USING EPA METHOD CORRECTED FOR WET WEIGHT

Boring ID	Peak MCB Concentration in Saturated UBA (mg/kg)	Wet Weight MCB Mass Integral Following HD (gm/sq ft)	Contour Area			
			>50,000 mg/kg (gm/sq ft)	>10,000 mg/kg (gm/sq ft)	>1,000 mg/kg (gm/sq ft)	<1,000 mg/kg (gm/sq ft)
DP- 1	480	0.0				0.0
DP- 2	210	0.0				
DP- 3	13,000	509.5		509.5		
DP- 4	45	0.0				
DP- 5	3,400	78.5			78.5	
DP- 7	16,000	674.4		674.4		
DP- 8	100	0.0				
DP- 9	<30					
DP- 10	<30					
DP- 11	<28					
DP- 12	550	0.0				
PSB- 1	2,400	42.1			42.1	
PSB- 2	7,100	227.2		227.2		
PSB- 3	3,000	63.8			63.8	
PSB- 4	45,000	3,011.2	3,011.2			
PSB- 5	14,000	562.9	562.9			
PSB- 6	27,000	1,402.4	1,402.4			
PSB- 7	<33					
PSB- 8	<30					
PSB- 9	2,000	28.0			28.0	
PSB- 10	44	0.0				
PSB- 11	3,200	71.1		71.1		
PSB- 12	1,400	7.3			7.3	
PSB- 13	<51					
PSB- 14	8,600	293.7		293.7		
PSB- 15	13,000	509.5		509.5		
PSB- 16	49	0.0				
PSB- 17	9,300	325.9		325.9		
PSB- 18	5,700	168.3		168.3		
PSB- 19	5,200	148.1		148.1		
SSB- 1	<21					
SSB- 2	23,000	1,115.3		1,115.3		
SSB- 3	<40					
SSB- 4	N/A					
SSB- 5	2,200	35.0			35.0	
SSB- 6	55,000	4,129.0	4,129.0			
SSB- 7	<2,000					
SSB- 8	<40					
SSB- 9	<45					
SSB- 10	<40					
SSB- 11	990	0.0				
SSB- 12	50,000	3,550.1	3,550.1			
SSB- 13	<40					
SSB- 14	<40					
SSB- 15	<34					
TSB- 1	<50					
TSB- 2	28,000	1,478.2		1,478.2		
TSB- 3	14,000	562.9		562.9		
TSB- 4	<30					
TSB- 5	44	0.0				
TSB- 6	<36					
TSB- 7	<34					
TSB- 8	13,000	509.5		509.5		
TSB- 9	47	0.0				
TSB- 10	46	0.0				
TSB- 11	280	0.0				
TSB- 12	<40					
TSB- 13	45	0.0				
TSB- 14	40	0.0				
TSB- 15	<35					
TSB- 16	<40					
C- 13	<30					
C- 30	8,300	280.1		280.1		
C- 42	<35					
C- 44	4,100	105.0			105.0	
C- 59	66	0.0				
S- 101/101A	36,000	2,142.0	2,142.0			
S- 201	N/A					
S- 202	N/A					
S- 203	N/A					
S- 204	N/A					
S- 301/301A	12,000	457.7		457.7		
S- 302A	54	0.0				0.0
S- 302E/302F	N/A					
S- 303/303A	1	0.0				
S- 304/304A	4,900	136.1	136.1			
S- 305/305A	81,000	7,784.2	7,784.2			
MW- 2	7,400	240.2				
UBT- 1	N/A		7,784.2			
UBT- 2	N/A		7,784.2			
UBT- 3	N/A		7,784.2			
LW- 1	N/A					

Notes:

For purposes of DNAPL mass estimation, recovery wells UBT-1 through UBT-3 were assigned an MCB mass integral value of 7,784.2 gm/sq ft, consistent with the value determined for S-305/305A.

\*MCB Mass x 2

Estimated DNAPL Mass Following Hydraulic Displacement (HD)					
Average (gm/sq ft) =	4,188.2	488.8	51.4	0.0	Subtotal
Area (sq ft) =	30,492	58,141	50,447	23,045	162,125
MCB Mass (lbs) =	280,957	62,518	5,702	0	349,177
DNAPL Mass (lbs)* =	561,913	125,036	11,405	0	698,354
% of Total Mass =	80.5%	17.9%	1.6%	0.0%	100.0%

Estimated DNAPL Mass Prior to Remediation from Table E-2B (lbs) = 841,894

Estimated Mobile DNAPL Mass in lbs (Mass Following HD Subtracted from Mass Prior to Remediation) = 143,540